State of California
The Resources Agency
Department of Water Resources

SP-W7 LAND AND WATERSHED MANAGEMENT EFFECTS ON WATER QUALITY

Task 1. Effects to Water Quality from Ongoing Land Uses and Management
Task 1B. Evaluation of Potential Effects to Water Quality

Oroville Facilities Relicensing
FERC Project No. 2100

AUGUST 2004

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REPORT SUMMARY

This report describes results of the monitoring program to assess effects of land use and watershed activities in and around the Oroville Facilities on water quality within the Project area. This study will provide information to be used to identify potential protection, mitigation, and enhancement measures.

Monitoring programs were designed to target specific land use and watershed activities with the potential to introduce contaminants into Project waters. The specific monitoring programs included: storm water sampling within the urbanized areas of Oroville; and pesticide treatment water quality sampling within the Oroville Wildlife Area. Data obtained from the monitoring programs were compared to water quality goals and criteria for protection of beneficial uses.

The water quality sampling sites were chosen to target the specific type of contaminant from each activity that could potentially affect Project waters. For the storm water sampling, parameters included physical parameters, bacteria, metals, nutrients, pesticides, petroleum byproducts, and toxicity. Water quality data collection was performed on November 7, November 14, and December 1, 2003.

The data indicate that storm runoff from the urbanized areas of Oroville could affect water quality in Project waters. Bacteria levels in the storm runoff were extremely high, and were well above water quality criteria. Most of the storm water samples had bacteria levels greater than 1,600 colonies/100 mL for total and fecal coliform, fecal streptococcus, and enterococcus bacteria. Aluminum, arsenic, iron and manganese exceeded water quality criteria, but were at the background levels found in other studies. Zinc also exceeded water quality criteria, and was well above the background levels found in other studies. These results indicate that the storm water runoff could potentially affect water quality of the Feather River.

Pesticide treatment sampling within the Oroville Wildlife Area included physical parameters, methoprene, and malathion. Sampling was performed monthly from May to November 2003. Methoprene, malathion, or their byproducts were not detected during sampling. There is no indication that pesticide application within the OWA is affecting water quality in Project waters.

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1.0 INTRODUCTION

The potential for land and watershed management activities within and adjacent to the Project area to affect water quality was a concern to the Environmental Work Group. The Task 1A interim report identified the potential sources of contamination to Project waters from land use activities, and proposed specific monitoring to assess this potential contamination.

1.1 BACKGROUND INFORMATION

Land and watershed management activities within and adjacent to the Project area have the potential to affect water quality and other aquatic and terrestrial resources. The Environmental Workgroup raised several issues related to land and watershed management effects on aquatic and terrestrial resources, including:

- protection of riparian areas and water quality by limiting disturbance in streamside management zones
- use of Best Management Practices during land use and management activities to avoid water quality degradation
- rehabilitation of deteriorating watersheds to reduce channel erosion, sedimentation, and sediment yield
- plan and manage on a watershed scale in cooperation with other agencies and private landowners
- effects of land use and management activities on terrestrial plant and animal communities and habitats.

Most of the land within the watershed upstream from Oroville Dam is owned by the federal government, and is predominantly managed by the U.S. Forest Service (USFS) with smaller holdings managed by the Bureau of Land Management (BLM) and some dispersed lands in private ownership. Some of the lands in private ownership along the tributaries to Lake Oroville have been developed with hydroelectric generation facilities, especially along the North Fork by the Pacific Gas and Electric Company (PG&E). A small portion of the land within the Project boundary upstream from Oroville Dam is managed by the USFS and BLM, but most of the land is owned by the State. The Department of Parks and Recreation (DPR) manages the water surface area of Lake Oroville and shoreline areas typically from the waterline to about the 1,100 foot elevation. The DFG manages the Oroville Wildlife Area downstream from the dam. A minor amount of private lands are included in the Project boundary, but adjacent residential and commercial developments on private property fall under the management jurisdiction of Butte County.

Lands within the watershed upstream from the dam are managed under several land and resource management plans, including the Plumas National Forest Land and Resource Management Plan (LRMP), BLM Redding Resource Management Plan (RRMP) and Record of Decision, and Butte County General Plan. Within the Project boundary upstream from the dam, land is managed under DWR's Recreation Plan for Lake Oroville State Recreation Area, USFS's LRMP, BLM's RRMP, and DPR's Resource Management Plan and General Development Plan for the Lake Oroville State Recreation Area. Downstream from the dam, lands are managed by the City of Oroville under the General Plan and by DFG's Oroville Wildlife Management Area Management Plan.

The myriad of ownership and land management plans and activities in conjunction with the relatively small portion of the watershed actually under control of DWR results in little ability of DWR to effectively manage land within the watershed. Nonetheless, DWR can work with adjacent property owners on land use and management activities, as well as those within the Project boundary that affect resources on Project lands.

A study plan was developed and approved by the Environmental Work Group to evaluate the effects from watershed and land use management activities on water quality in 2002. Task 1 of that study plan was to evaluate the potential for watershed and land use management activities to affect water quality in the Project area and develop appropriate monitoring. The results of that study and proposed monitoring were presented in the Task 1A report to the Environmental Work Group in 2003. This report presents the results of the assessment and monitoring performed under the two-year monitoring plan accepted by the Environmental Work Group.

1.1.1 Statutory/Regulatory Requirements

Demonstration of compliance with water quality standards and other appropriate requirements are necessary in the application for water quality certification. Information obtained from the study was used to determine effects from land use activities on the physical and chemical components of water quality, and the need for mitigation for impacts to water quality. This analysis is required for water quality certification by the State Water Resources Control Board. The water quality certification is needed for license renewal with the Federal Energy Regulatory Commission.

1.1.2 Study Area

The study area is generally within the FERC Project boundary, but also includes adjacent lands and waterways for effects to Project waters, and downstream for Project effects in the Feather River. Specific water bodies included in the study area are Lake Oroville, Feather River downstream from Oroville Dam within the Project boundary, Diversion Pool, Thermalito Forebay and Afterbay, and Oroville Wildlife Area ponds.

1.2 DESCRIPTION OF FACILITIES

The Oroville Facilities were developed as part of the State Water Project (SWP), a water storage and delivery system of reservoirs, aqueducts, power plants, and pumping plants. The main purpose of the SWP is to store and distribute water to supplement the needs of urban and agricultural water users in northern California, the San Francisco Bay area, the San Joaquin Valley, and southern California. The Oroville Facilities are also operated for flood management, power generation, to improve water quality in the Delta, provide recreation, and enhance fish and wildlife.

FERC Project No. 2100 encompasses 41,100 acres and includes Oroville Dam and Reservoir, three power plants (Hyatt Pumping-Generating Plant, Thermalito Diversion Dam Power Plant, and Thermalito Pumping-Generating Plant), Thermalito Diversion Dam, the Feather River Fish Hatchery and Fish Barrier Dam, Thermalito Power Canal, Oroville Wildlife Area, Thermalito Forebay and Forebay Dam, Thermalito Afterbay and Afterbay Dam, and transmission lines, as well as a number of recreational facilities. An overview of these facilities is provided on Figure 1.2-1. The Oroville Dam, along with two small saddle dams, impounds Lake Oroville, a 3.5-million-acre-feet (maf) capacity storage reservoir with a surface area of 15,810 acres at its normal maximum operating level.

The hydroelectric facilities have a combined licensed generating capacity of approximately 762 megawatts (MW). The Hyatt Pumping-Generating Plant is the largest of the three power plants with a capacity of 645 MW. Water from the six-unit underground power plant (three conventional generating and three pumping-generating units) is discharged through two tunnels into the Feather River just downstream of Oroville Dam. The plant has a generating and pumping flow capacity of 16,950 cfs and 5,610 cubic feet per second (cfs), respectively. Other generation facilities include the 3-MW Thermalito Diversion Dam Power Plant and the 114-MW Thermalito Pumping-Generating Plant.

Thermalito Diversion Dam, four miles downstream of the Oroville Dam creates a tail water pool for the Hyatt Pumping-Generating Plant and is used to divert water to the Thermalito Power Canal. The Thermalito Diversion Dam Power Plant is a 3-MW power plant located on the left abutment of the Diversion Dam. The power plant releases a maximum of 615 cfs of water into the river.

The Power Canal is a 10,000-foot-long channel designed to convey generating flows of 16,900 cfs to the Thermalito Forebay and pump-back flows to the Hyatt Pumping-Generating Plant. The Thermalito Forebay is an off-stream regulating reservoir for the 114-MW Thermalito Pumping-Generating Plant. The Thermalito Pumping-Generating Plant is designed to operate in tandem with the Hyatt Pumping-Generating Plant and has generating and pump-back flow capacities of 17,400 cfs and 9,120 cfs, respectively. When in generating mode, the Thermalito Pumping-Generating Plant discharges into the Thermalito Afterbay, which is contained by a 42,000-foot-long earth-fill dam. The Afterbay is used to release water into the Feather River downstream of the Oroville Facilities, helps regulate the power system, provides storage for pump-back operations, and provides recreational opportunities. Several local irrigation districts receive water from the Afterbay.

The Feather River Fish Barrier Dam is downstream of the Thermalito Diversion Dam and immediately upstream of the Feather River Fish Hatchery. The flow over the dam maintains fish habitat in the low-flow channel of the Feather River between the dam and the Afterbay outlet, and provides attraction flow for the hatchery. The hatchery was intended to compensate for spawning grounds lost to returning salmon and steelhead trout from the construction of Oroville Dam. The hatchery can accommodate 15,000 and 20,000 adult fish annually.

The Oroville Facilities support a wide variety of recreational opportunities. They include: boating (several types), fishing (several types), fully developed and primitive camping (including boat-in and floating sites), picnicking, swimming, horseback riding, hiking, off-road bicycle riding, wildlife watching, hunting, and visitor information sites with cultural and informational displays about the developed facilities and the natural environment. There are major recreation facilities at Loafer Creek, Bidwell Canyon, the Spillway, North and South Thermalito Forebay, and Lime Saddle. Lake Oroville has two full-service marinas, five car-top boat launch ramps, ten floating campsites, and seven dispersed floating toilets. There are also recreation facilities at the Visitor Center and the OWA.

The Oroville Wildlife Area comprises approximately 11,000-acres west of Oroville that is managed for wildlife habitat and recreational activities. It includes the Thermalito Afterbay and surrounding lands (approximately 6,000 acres) along with 5,000 acres adjoining the Feather River. The 5,000-acre area straddles 12 miles of the Feather River, which includes willow and cottonwood lined ponds, islands, and channels. Recreation areas include dispersed recreation (hunting, fishing, and bird watching), plus recreation at developed sites, including Monument Hill day use area, model airplane grounds, three boat launches on the Afterbay and two on the river, and two primitive camping areas. California Department of Fish and Game's (DFG) habitat enhancement program includes a wood duck nest-box program and dry land farming for nesting cover and improved wildlife forage. Limited gravel extraction also occurs in a number of locations.

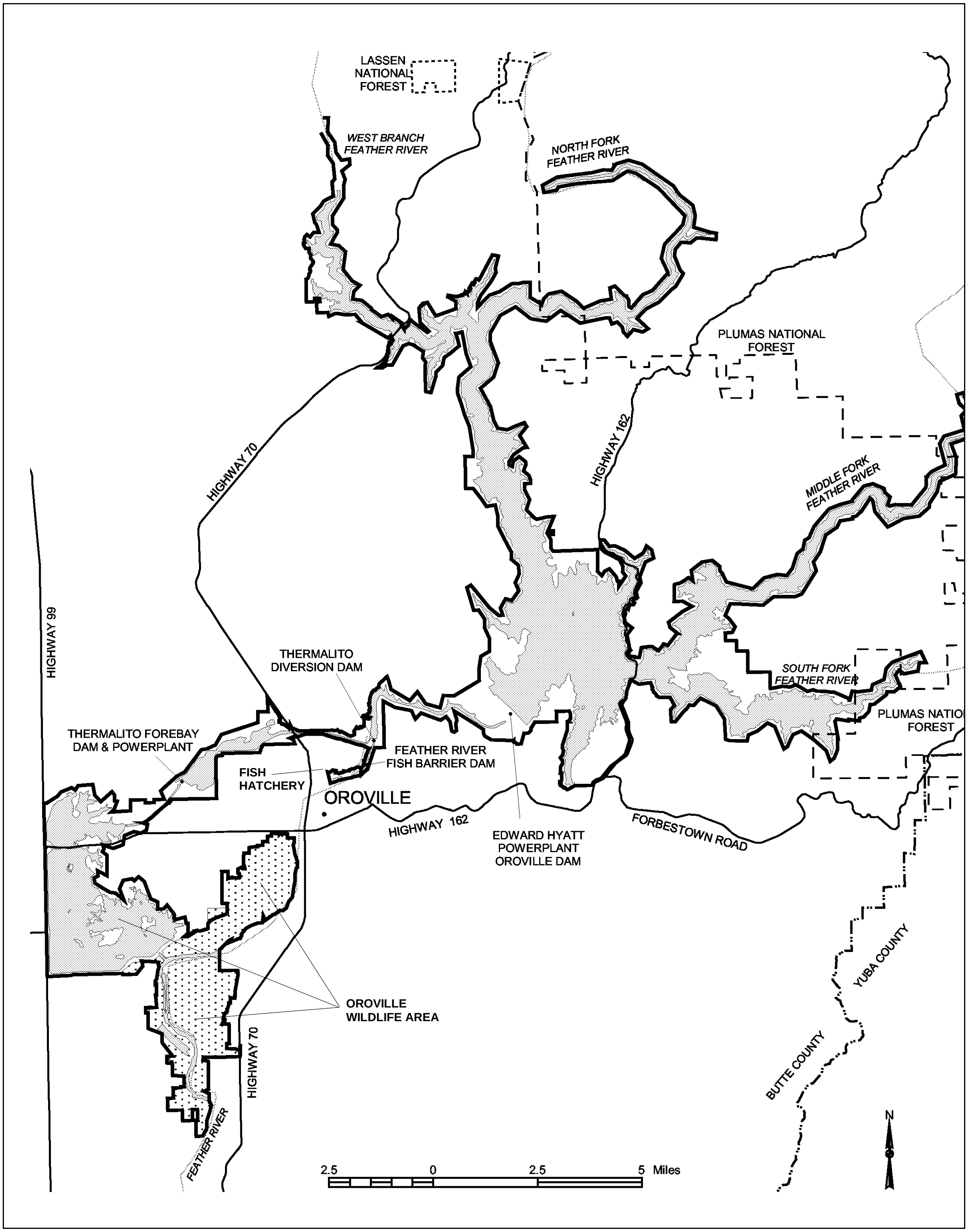


Figure 1.2-1. Oroville Facilities FERC Project Boundary.

1.3 CURRENT OPERATIONAL CONSTRAINTS

Operation of the Oroville Facilities varies seasonally, weekly and hourly, depending on hydrology and the objectives DWR is trying to meet. Typically, releases to the Feather River are managed to conserve water while meeting a variety of water delivery requirements, including flow, temperature, fisheries, recreation, diversion and water quality. Lake Oroville stores winter and spring runoff for release to the Feather River as necessary for Project purposes. Meeting the water supply objectives of the SWP has always been the primary consideration for determining Oroville Facilities operation (within the regulatory constraints specified for flood control, in-stream fisheries, and downstream uses). Power production is scheduled within the boundaries specified by the water operations criteria noted above. Annual operations planning is conducted for multi-year carry over. The current methodology is to retain half of the Lake Oroville storage above a specific level for subsequent years. Currently, that level has been established at 1,000,000 acre-feet (af); however, this does not limit draw down of the reservoir below that level. If hydrology is drier than expected or requirements greater than expected, additional water would be released from Lake Oroville. The operations plan is updated regularly to reflect changes in hydrology and downstream operations. Typically, Lake Oroville is filled to its maximum annual level of up to 900 feet above mean sea level (msl) in June and then can be lowered as necessary to meet downstream requirements, to its minimum level in December or January. During drier years, the lake may be drawn down more and may not fill to the desired levels the following spring. Project operations are directly constrained by downstream operational constraints and flood management criteria as described below.

1.3.1 Downstream Operation

An August 1983 agreement between DWR and DFG entitled, “Agreement Concerning the Operation of the Oroville Division of the State Water Project for Management of Fish & Wildlife,” sets criteria and objectives for flow and temperatures in the low flow channel and the reach of the Feather River between Thermalito Afterbay and Verona. This agreement: (1) establishes minimum flows between Thermalito Afterbay Outlet and Verona which vary by water year type; (2) requires flow changes under 2,500 cfs to be reduced by no more than 200 cfs during any 24-hour period, except for flood management, failures, etc.; (3) requires flow stability during the peak of the fall-run Chinook spawning season; and (4) sets an objective of suitable temperature conditions during the fall months for salmon and during the later spring/summer for shad and striped bass.

1.3.1.1 Instream Flow Requirements

The Oroville Facilities are operated to meet minimum flows in the Lower Feather River as established by the 1983 agreement (see above). The agreement specifies that Oroville Facilities release a minimum of 600 cfs into the Feather River from the

Thermalito Diversion Dam for fisheries purposes. This is the total volume of flows from the diversion dam outlet, diversion dam power plant, and the Feather River Fish Hatchery pipeline.

Generally, the instream flow requirements below Thermalito Afterbay are 1,700 cfs from October through March, and 1,000 cfs from April through September. However, if runoff for the previous April through July period is less than 1,942,000 af (i.e., the 1911-1960 mean unimpaired runoff near Oroville), the minimum flow can be reduced to 1,200 cfs from October to February, and 1,000 cfs for March. A maximum flow of 2,500 cfs is maintained from October 15 through November 30 to prevent spawning in overbank areas that might become de-watered.

1.3.1.2 Temperature Requirements

The Diversion Pool provides the water supply for the Feather River Fish Hatchery. The hatchery objectives are 52 ºF for September, 51 ºF for October and November, 55 ºF for December through March, 51 ºF for April through May 15, 55 ºF for last half of May, 56 ºF for June 1-15, 60 ºF for June 16 through August 15, and 58 ºF for August 16-31. A temperature range of plus or minus 4 ºF is allowed for objectives, April through November.

There are several temperature objectives for the Feather River downstream of the Afterbay Outlet. During the fall months, after September 15, the temperatures must be suitable for fall-run Chinook. From May through August, they must be suitable for shad, striped bass, and other warmwater fish.

The National Marine Fisheries Service has also established an explicit criterion for steelhead trout and spring-run Chinook salmon. Memorialized in a biological opinion on the effects of the Central Valley Project and SWP on Central Valley spring-run Chinook and steelhead as a reasonable and prudent measure; DWR is required to control water temperature at Feather River mile 61.6 (Robinson’s Riffle in the low-flow channel) from June 1 through September 30. This measure requires water temperatures less than or equal to 65 ºF on a daily average. The requirement is not intended to preclude pump-back operations at the Oroville Facilities needed to assist the State of California with supplying energy during periods when the California ISO anticipates a Stage 2 or higher alert.

The hatchery and river water temperature objectives sometimes conflict with temperatures desired by agricultural diverters. Under existing agreements, DWR provides water for the Feather River Service Area (FRSA) contractors. The contractors claim a need for warmer water during spring and summer for rice germination and growth (i.e., 65 ºF from approximately April through mid May, and 59 ºF during the remainder of the growing season). There is no obligation for DWR to meet the rice water temperature goals. However, to the extent practical, DWR does use its operational flexibility to accommodate the FRSA contractor's temperature goals.

1.3.1.3 Water Diversions

Monthly irrigation diversions of up to 190,000 (July 2002) af are made from the Thermalito Complex during the May through August irrigation season. Total annual entitlement of the Butte and Sutter County agricultural users is approximately 1 maf. After meeting these local demands, flows into the lower Feather River continue into the Sacramento River and into the Sacramento-San Joaquin Delta. In the northwestern portion of the Delta, water is pumped into the North Bay Aqueduct. In the south Delta, water is diverted into Clifton Court Forebay where the water is stored until it is pumped into the California Aqueduct.

1.3.1.4 Water Quality

Flows through the Delta are maintained to meet Bay-Delta water quality standards arising from DWR's water rights permits. These standards are designed to meet several water quality objectives such as salinity, Delta outflow, river flows, and export limits. The purpose of these objectives is to attain the highest water quality, which is reasonable, considering all demands being made on the Bay-Delta waters. In particular, they protect a wide range of fish and wildlife including Chinook salmon, Delta smelt, striped bass, and the habitat of estuarine-dependent species.

1.3.2 Flood Management

The Oroville Facilities are an integral component of the flood management system for the Sacramento Valley. During the wintertime, the Oroville Facilities are operated under flood control requirements specified by the U.S. Army Corps of Engineers (USACE). Under these requirements, Lake Oroville is operated to maintain up to 750,000 af of storage space to allow for the capture of significant inflows. Flood control releases are based on the release schedule in the flood control diagram or the emergency spillway release diagram prepared by the USACE, whichever requires the greater release. Decisions regarding such releases are made in consultation with the USACE.

The flood control requirements are designed for multiple use of reservoir space. During times when flood management space is not required to accomplish flood management objectives, the reservoir space can be used for storing water. From October through March, the maximum allowable storage limit (point at which specific flood release would have to be made) varies from about 2.8 to 3.2 maf to ensure adequate space in Lake Oroville to handle flood flows. The actual encroachment demarcation is based on a wetness index, computed from accumulated basin precipitation. This allows higher levels in the reservoir when the prevailing hydrology is dry while maintaining adequate flood protection. When the wetness index is high in the basin (i.e., wetness in the watershed above Lake Oroville), the flood management space required is at its greatest amount to provide the necessary flood protection. From April through June, the maximum allowable storage limit is increased as the flooding potential decreases, which allows capture of the higher spring flows for use later in the year. During September, the maximum allowable storage decreases again to prepare for the next flood season. During flood events, actual storage may encroach into the flood reservation zone to prevent or minimize downstream flooding along the Feather River.

2.0 NEED FOR STUDY

The study will be used to demonstrate the post-Project effectiveness of the land use practices on the biological, physical, and chemical integrity of waters within the Project area. The U. S Fish and Wildlife Service and National Oceanic and Atmospheric Administration Fisheries require this information to determine Project effects on the habitat of listed species, including salmon and steelhead. The State Water Resources Control Board will use this data in their water quality compliance evaluation for the issuance of a Section 401 Water Quality Certification.

3.0 STUDY OBJECTIVE(S)

The objective of this study is to determine the effects of watershed and land use management activities on water quality of Project waters. This study will provide information to be used to identify potential protection, mitigation, and enhancement measures.

4.0 METHODOLOGY

This study plan addressed the potential contamination concerns that could affect Project water quality from watershed and land use management activities in the vicinity of the Oroville Facilities Project. Concerns that were identified in the SP-W7 Task 1A report include potential contamination from pesticides, sediments, nutrients, bacteria, petroleum byproducts, and metals.

The water quality sampling sites were chosen to reflect the specific type of contaminant from each activity that could be potentially affecting Project waters. Water quality monitoring for most parameters of concern occurred at the water quality stations sampled under SP-W1. This study monitored specific contamination sources that were not covered under other study plans. Miscellaneous land uses around Lake Oroville and the Thermalito Forebay and Afterbay were monitored by visual observation for turbidity plumes to Project waters, in conjunction with agricultural land uses monitoring.

Water quality sampling to evaluate the potential effects to water quality by land use activities were separated into specific monitoring programs, and will be presented separately.

4.1 STORMWATER SAMPLING

Residential and commercial land uses within the urbanized areas around the Oroville Facilities were monitored at three stormwater discharge outfalls from the City of Oroville to the Feather River (Figure 4.1-1) and one discharge outfall from Kelly Ridge to Lake Oroville (Figure 4.1-2) during the first three storm events. Discharges were analyzed for bacteria, metals, minerals, nutrients, pesticides, petroleum byproducts, physical parameters, and toxicity through use of toxicity bioassays. Additionally, three river stations (Feather River upstream from the Fish Hatchery, Feather River downstream from the Fish Hatchery, and Feather River downstream from Highway 162 bridge) were sampled for toxicity analysis only.

Grab samples for toxicity analyses were collected by first rinsing pre-cleaned, five-gallon polyethylene bottles three times in ambient water at the sampling site. The bottles were then held approximately 6 inches below the water's surface at the river locations and filled with approximately 5 gallons of sample water. The drain samples were filled directly from the ends of culverts or pipes. The sample bottles were then labeled with the station name code, sampling date and time, sampler's name, placed into ice chests, and preserved with ice at a temperature of approximately 39 ºF. Station name codes consisted of the station name initials with an identifying acronym, as in:

- OSDRN - Oliver Street storm drain (Figure 4.1-3);
- PSDRN - Pine Street storm drain (Figure 4.1-4);
- RSDRN – Robinson Street storm drain (Figure 4.1-5);

- KRDRN – Kelly Ridge drainage outfall (Figures 4.1-6);
- FR162 – Feather River downstream from Highway 162 bridge;
- FRDFH – Feather River downstream from fish hatchery; and,
- FRFBD – Feather River at Oroville.

Samples were delivered to the Pacific EcoRisk Laboratory (PER) in Martinez, California, within twenty-four hours of collection. PER staff removed an aliquot from each water sample for analysis of initial water quality characteristics, including temperature, pH, dissolved oxygen, alkalinity, hardness, electrical conductivity, and total ammonia. The remaining sample water was stored at 39 ºF until used in setting up or maintaining the toxicity tests.

Sampling occurred on November 7 and 14, 2003, and December 1, 2003. Stormwater sampling for the SP-W3 recreational water quality was performed in conjunction with this sampling.

Figure 4.1-1. Stormwater sampling sites in and around the city of Oroville.

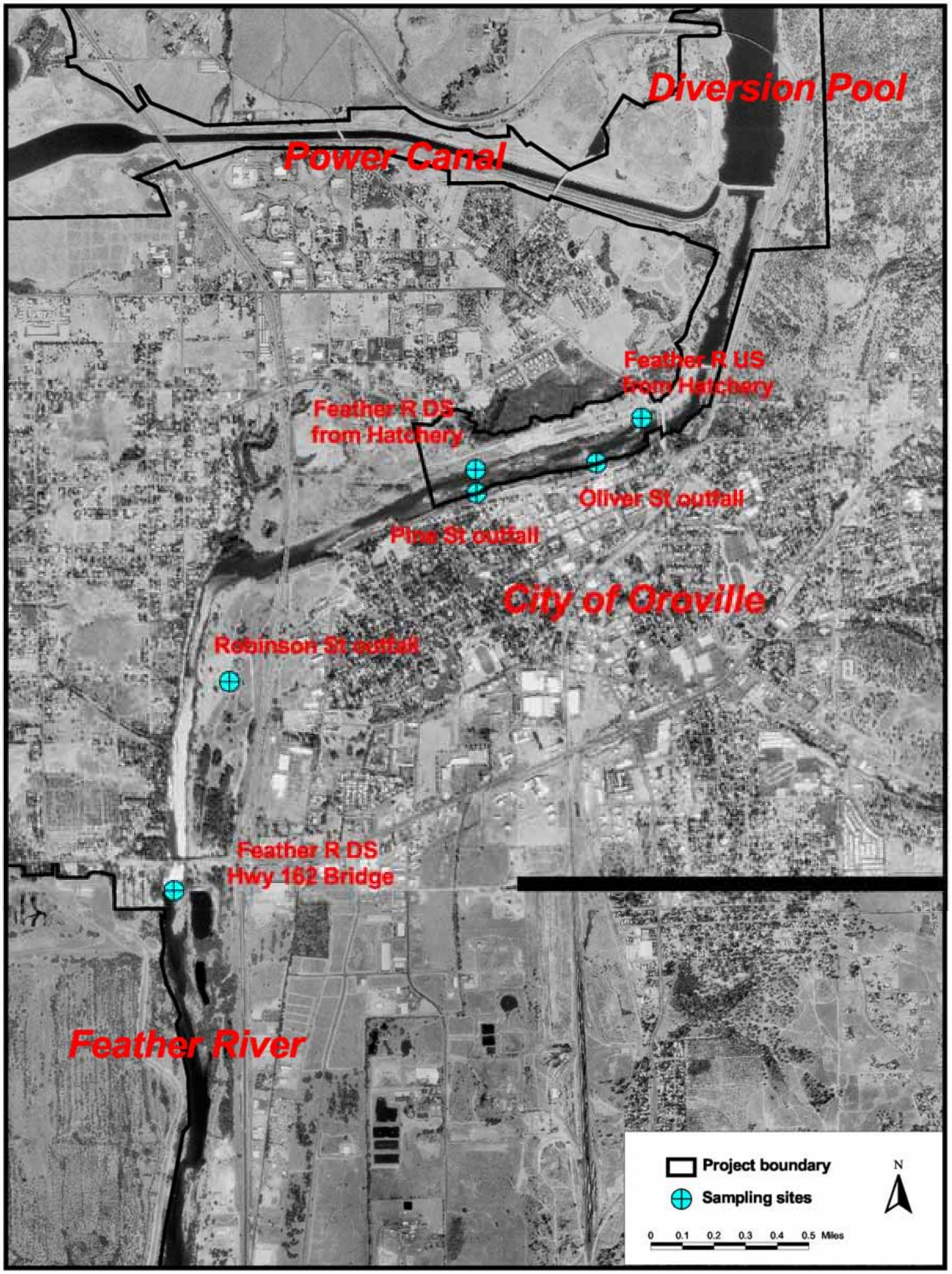


Figure 4.1-2. Stormwater sampling site at Kelly Ridge.

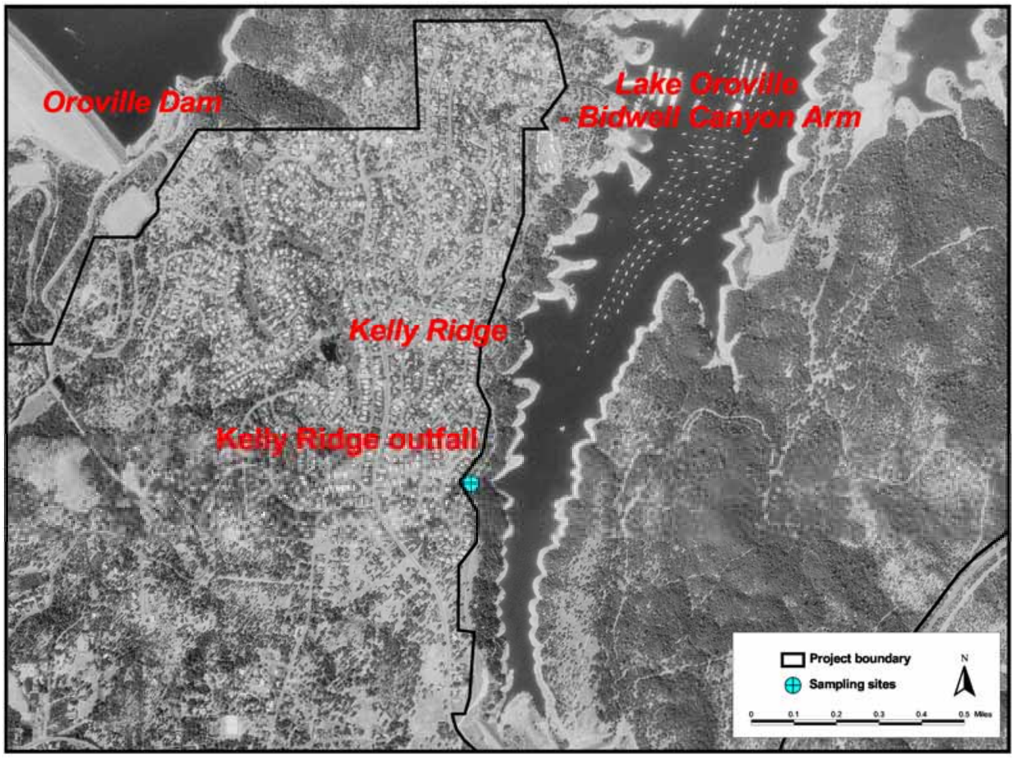


Figure 4.1-3. Oliver Street outfall, City of Oroville.

Figure 4.1-4 Pine Street outfall, City of Oroville.

Figure 4.1-5. Robinson Street outfall, City of Oroville.

Figure 4.1-6. Kelly Ridge drainage.

4.2 PESTICIDE TREATMENTS

The Butte County Mosquito and Vector Control District (MVCD) treats the open water ponds in the Oroville Wildlife Area with methoprene and malathion for mosquito control. Both chemicals are approved by the U.S. Environmental Protection Agency (USEPA) for this use. Methoprene, which is an insect growth regulator, is applied to water to inhibit mosquito maturation. At concentrations applied for mosquito control, methoprene is considered to be non-toxic to birds, fish and most aquatic invertebrates, though midges and large crustaceans (such as crayfish) may be affected. The breakdown products of methoprene, which are called retinoids, may mimic retinoic acid, which is a water soluble derivative of vitamin A. Retinoic acid controls the limb development in all vertebrates and limb regeneration in amphibians. Laboratory tests with elevated levels of retinoic acid have resulted in limb deformities in frogs. The MVCD targets small, isolated water bodies for treatment with methoprene. Larger water bodies that support fish usually do not need treatment for mosquito control.

Malathion, an organophosphate pesticide, is applied as a mist to control adult mosquitoes. Malathion is toxic to aquatic organisms and has been implicated in the decline of frog populations.

Water samples were collected monthly for analyses of methoprene and malathion from May 2003 to November 2003 from six persistent ponds that are treated with methoprene or are in the vicinity of malathion treatments, as well as along the bank of the Feather River adjacent to the treated area to determine any leaching to the river (Figures 4.2-1 through 10). In addition, water temperatures were measured along the bank and compared to pond temperatures to determine if any significant leaching to the river could be occurring. The ponds were also sampled for zooplankton and aquatic invertebrates. Two control ponds in untreated areas were sampled for comparison.

Figure 4.2-1. Methoprene and malathion sampling sites within the Oroville Wildlife Area.

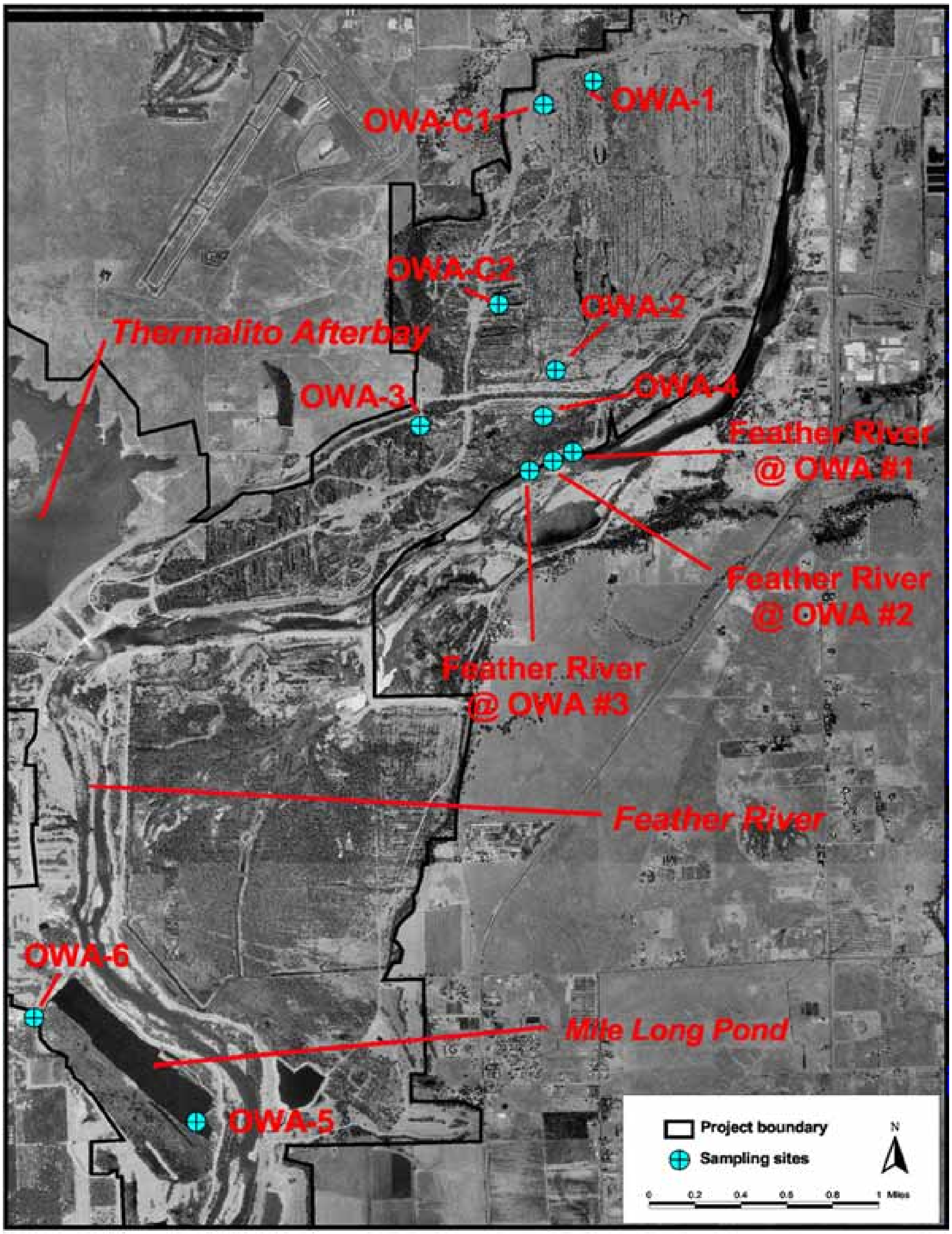


Figure 4.2-2. Methoprene and malathion sampling site OWA-1.

Figure 4.2-3. Methoprene and malathion sampling site OWA-2

Figure 4.2-4. Methoprene and malathion sampling site OWA-3.

Figure 4.2-5. Methoprene and malathion sampling site OWA-4 (Robinson Riffle Pond).

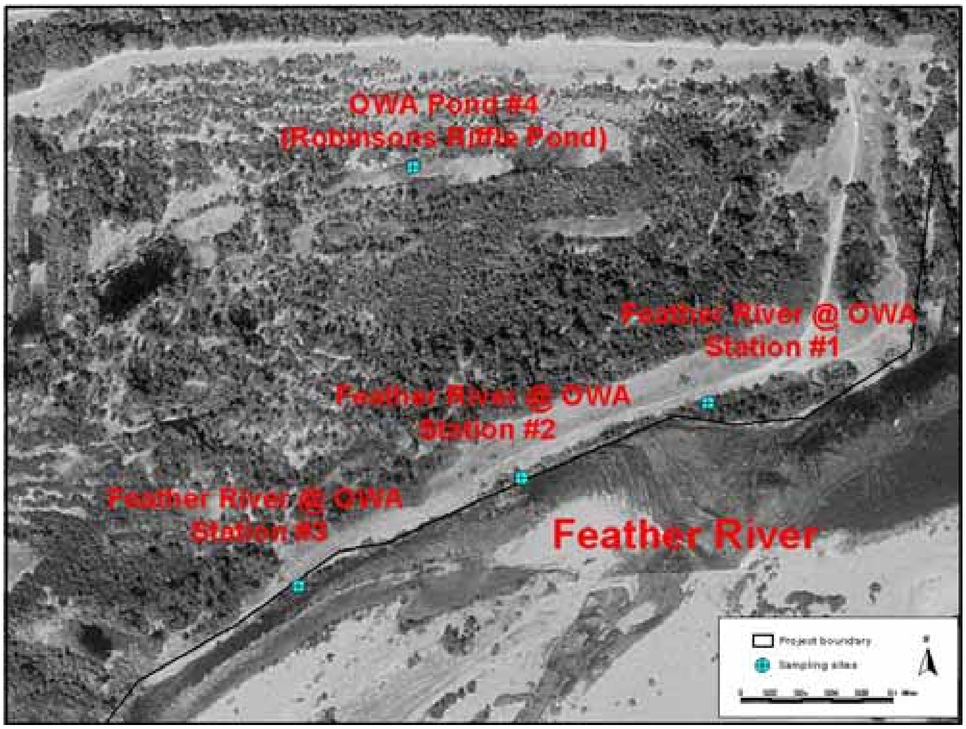
Figure 4.2-6. Methoprene and malathion sampling site OWA-5 (Mile Long Pond).

Figure 4.2-7. Methoprene and malathion sampling site OWA-6.

Figure 4.2-8. Methoprene and malathion sampling site OWA-C1.

Figure 4.2-9. Methoprene and malathion sampling site OWA-C2.

Figure 4.2-10. Feather River at the Oroville Wildlife Area water temperature sites.



5.0 STUDY RESULTS

The watershed and land use water quality sampling programs were conducted according to the monitoring plan approved by the Environmental Work Group.

5.1 STORMWATER SAMPLING

Storm event sampling occurred on November 7, November 14, and December 1, 2003. The rainfall tended to be patchy, with some areas receiving relatively heavy rains and other areas receiving little or no rain. Attempts at sampling were tried later in the month of December, but the rains were too light to produce enough flow to sample.

5.1.1 Physical parameters

Physical parameters were measured at each sampling point, including water temperature, conductivity, dissolved oxygen, and pH (Table 5.1.1-1).

The water temperature of the runoff ranged from 53.6 to 59.7 ^{o}F at all stations during all of the sampling events. Conductivity tended to be uniformly low, ranging from 17 to 122 µmhos/cm, with all but one measurement below 100 µmhos/cm. One exceptionally high conductivity was measured at the Kelly Ridge outfall, which had a value of 377 umhos/cm. Dissolved oxygen was found to be relatively high, ranging from 8.4 to 10.0 mg/L. pH ranged from 6.4 to 7.6 pH units, and averaged 6.8 pH units across all stations.

Table 5.1.1-1. Stormwater sampling - Physical parameters.

Station	Date	Water Temperature (^{o}F)	Conductivity (µmhos/cm)	Dissolved Oxygen (mg/L)	pH
Kelly Ridge	11/7/03	57.7	122	9.0	7.0
	11/14/03	54.9	68	12.0	7.4
	12/1/03	56.5	377	8.6	7.6
Oliver Street	12/1/03	53.6	17	9.9	6.8
Pine Street	11/7/03	57.4	41	10.0	6.8
	11/14/03	59.7	53	8.4	7.0
	12/1/03	55.4	32	8.4	6.8
Robinson Street	11/7/03	56.8	35	9.6	6.8
	11/14/03	57.9	38	8.6	6.4
	12/1/03	55.9	41	9.3	6.7

5.1.2 Bacteria

Bacteria samples were taken from all stations for fecal and total coliform, fecal streptococcus, and enterococcus. The results of the bacterial analyses were compared to USEPA and DHS bacterial water quality criteria for total and fecal coliforms and enterococcus. A water quality criterion for fecal streptococcus has not been established by USEPA or DHS. However, the test for fecal streptococcus is necessary to detect enterococcus, which is a pathogen that does have established criteria.

Without exception, all of the water samples tested very high in bacteria levels, with all of the samples exceeding DHS recommended bacteria water quality criteria of 400 colonies/100 mL for fecal coliform bacteria and 33 colonies/100 mL for enterococcus (Table 5.1.2-1). The water samples also exceeded the USEPA bacteria water quality criterion for enterococcus of 61colonies/100 mL. The bacteria levels found in these water samples may have also exceeded the CDHS recommended criterion for total coliform bacteria of 10,000 colonies/100 mL. However, the testing methodology utilized by the lab will measure only up to 1,600 colonies/100 mL. Any bacteria levels higher than 1,600 colonies/100 mL are simply reported as ">1600/100 mL." All of the water samples had total coliform bacteria levels at >1,600 colonies/100 mL.

Table 5.1.2-1. Stormwater sampling - Bacteria.

Station	Date	Total Coliform #/100 ml	Fecal Coliform #/100 ml	Entero-coccus[1] #/100 ml	Fecal Strepto-coccus #/100 ml
Kelly Ridge	11/7/03	>1600	**>1600**	**>1600**	>1600
	12/1/03	>1600	**>1600**	**500**	500
Oliver Street	12/1/03	>1600	**>1600**	**>1600**	>1600
Pine Street	11/7/03	>1600	**>1600**	**>1600**	>1600
	12/1/03	>1600	**>1600**	**>1600**	>1600
Robinson Street	11/7/03	>1600	**>1600**	**>1600**	>1600
	12/1/03	>1600	**>1600**	**>1600**	>1600

[1]EPA criteria – freshwater designated bathing beach area: Enterococci 61 per 100 ml
CDHS recommended freshwater public beach criteria: Total coliforms 10,000/100 ml; Fecal coliforms 400/100 ml; Enterococcus 33/100 ml
[2]Bold indicates values exceeds water quality criteria

5.1.3 Metals

Water samples were taken at each sampling point for the analyses of total and dissolved metals, including aluminum, arsenic, cadmium, chromium, copper, iron, lead, manganese, nickel, selenium, silver, and zinc. Water samples were also taken for the analyses of total and methyl mercury.

The detected amounts of most of the metals (Appendices 1 and 2) did not exceed water quality criteria. Five metals (aluminum, arsenic, iron, manganese, and zinc) did exceed water quality criteria at some time in the sampling (Table 5.1.3-1). Total aluminum exceeded water quality criteria in seven of nine samples. Total arsenic levels exceeded water criteria in every sample, while iron and manganese exceeded criteria four times.

The criteria for total and dissolved zinc are determined as a function of hardness (RWQCB 2003). Total and dissolved zinc exceeded water quality criteria in half of the water samples under the California Toxics Rule or USEPA National Recommended Water Quality Criteria for the protection of aquatic life.

Table 5.1.3-1. Metals that exceeded water quality criteria.

Station Name	Date	Total Aluminum (µg/L)	Total Arsenic (µg/L)	Total Iron (µg/L)	Total Manganese (µg/L)	Total Zinc (µg/L)	Diss. Zinc (µg/L)
Kelly Ridge	11/7/03	71.8	**0.603**[3,4,5,6]	213	**63.5**[9]	5.26	2.71
	11/14/03	**462**[1,2]	**0.71**[3,4,5,6]	**811**[7]	**60.8**[9]	11.6	4.17
	12/1/03	30.4	**0.554**[3,4,5,6]	140	**77.2**[9]	4.32	2.31
Oliver Street	12/1/03	-	**0.499**[3,4,5,6]	205	14	33.6	**38.4**[11]
Pine Street	11/7/03	**130**[1]	**0.588**[3,4,5,6]	222	21	**43.9**[10]	27.3
	11/14/03	**135**[1]	**0.566**[3,4,5,6]	**1009**[7,8]	43.5	**89.2**[10]	**39.8**[11]
	12/1/03	**580**[1,2]	**0.509**[3,4,5,6]	178	12.2	**41.1**[10]	**58.1**[11]
Robinson Street	11/7/03	**114**[1]	**0.629**[3,4,5,6]	**501**[7]	26.8	**49.1**[10]	33.7
	11/14/03	**322**[1,2]	**0.694**[3,4,5,6]	**933**[7]	42	**85.3**[10]	**37.3**[11]
	12/1/03	**595**[1,2]	**0.603**[3,4,5,6]	213	**63.5**[9]	5.26	**63.5**[11]

(Source: RWQCB, 2003)
1 Exceeds the USEPA Recommended Ambient Water Quality Criteria for Freshwater Aquatic Life Protection continuous concentration (4-day average) of 87µg/L
2 Exceeds the DHS drinking water secondary MCL of 200 µg/L
3 Exceeds the California EPA Cancer Potency Factor as a Drinking Water Level - 0.023 µg/L
4 Exceeds the USEPA Integrated Risk Information System One-in-a-Million Incremental Cancer Risk Estimate for Drinking Water - 0.02 µg/L
5 Exceeds the USEPA National Recommended Ambient Water Quality Criteria for human Health and Welfare Protection for Sources of Drinking Water (water +organisms) - 0.018 µg/L
6 Exceeds the USEPA National Recommended Ambient Water Quality Criteria for human Health and Welfare Protection for Sources of Drinking Water (aquatic organism consumption only) of 0.14 µg/L
7 Exceeds the DHS and USEPA Drinking Water Standard Secondary MCL of 300 µg/L
8 Exceeds the USEPA National Recommended Ambient Water Quality Criteria for Freshwater Aquatic Life Protection Continuous Concentration (4-day average) of 1,000 µg/L
9 Exceeds the DHS and USEPA Drinking Standards Secondary MCL of 50 µg/L

10 Exceeds the USEPA Recommended Ambient Water Quality Criteria to Protect Freshwater Aquatic Life for Total Recoverable Zinc
11 Exceeds the California Toxics Rule Criteria to Protect Freshwater Aquatic Life for Dissolved Zinc

The USEPA California Toxics Rule criteria for total mercury is 0.05 µg/L (50 ng/L) for drinking water sources (consumption of water and aquatic organisms), while the USEPA National Ambient Water Quality Criteria set a limit of 0.77 µg/L (770 ng/L) as a 4-day average and 1.4 µg/L 1,400 ng/L) as a 1-hour average for aquatic life protection (RWQCB, 2003). For methyl mercury, the USEPA IRIS Reference Dose for toxicity to humans is 0.07 µg/L (70 ng/L). Overall, the detected amounts of total mercury ranged from 0.00101 µg/L (1.01 ng/L) to 0.0309 µg/L (30.90 ng/L). Methyl mercury ranged from <0.000026 µg/L (0.026 ng/L) to 0.000682 µg/L (0.682 ng/L). At these levels, total and methyl mercury levels in samples collected during this study (Table 5.1.3-2) did not exceed water quality criteria.

Table 5.1.3-2. Total and methyl mercury.

Name	Date	Total Mercury (ng/L)	Methyl Mercury (ng/L)
Kelly Ridge	11/07/03	3.26	0.038
	11/14/03	9.17	0.099
	12/01/03	1.01	0.026
Oliver Street	12/01/03	16.10	0.121
Pine Street	11/07/03	10.40	0.264
	11/14/03	11.50	0.285
	12/01/03	30.90	0.682
Robinson Street	11/07/03	9.60	0.324
	11/14/03	14.70	0.284
	12/01/03	24.50	0.458

5.1.4 Minerals and Nutrients

Water samples were taken at each sampling point for the analyses of minerals, including dissolved boron, dissolved and total calcium, dissolved and total magnesium, dissolved potassium, and dissolved sodium, and nutrients, including dissolved ammonia, dissolved nitrite/nitrate, dissolved orthophosphate, dissolved sulfate, total phosphorus, and total ammonia. Results showed that no water samples contained minerals (Table 5.1.4-1) or nutrients (Table 5.1.4-2) in concentrations high enough to exceed water quality criteria, though most of these parameters do not have developed criteria.

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Table 5.1.4-1. Stormwater sampling - Minerals.

Station	Date	Diss. Boron (mg/L)	Diss. Calcium (mg/L)	Total Calcium (mg/L)	Diss. Chloride (mg/L)	Diss. Magnesium (mg/L)	Diss. Potassium (mg/L)	Total Magnesium (mg/L)	Diss. Sodium (mg/L)
Kelly Ridge	11/7/03	<1	17	16	6	16	0.6	15	6
	11/14/03	<0.1	4	11	1	4	0.6	9	2
	12/1/03	<0.1	26	25	9	26	<0.5	25	10
Oliver St	12/1/03	<0.1	1	2	<1	<1	0.9	<1	<1
Pine Street	11/7/03	<0.1	3	3	<1	1	3.8	1	1
	11/14/03	<0.1	4	4	2	1	4.8	1	1
	12/1/03	<0.1	2	4	1	<1	3	2	<1
Robinson Street	11/7/03	<0.1	3	4	<1	1	2.2	1	1
	11/14/03	<0.1	2	3	1	1	2.2	1	1
	12/1/03	<0.1	5	5	2	1	1.8	2	2

Table 5.1.4-2. Stormwater sampling - Nutrients

Station	Date	Dissolved Ammonia (mg/L as N)	Total Ammonia (mg/L)	Dissolved Nitrite/Nitrate (mg/L as N)	Dissolved Orthophosphate (mg/L as P)	Total Phosphorus (mg/L)	Dissolved Sulfate (mg/L)
Kelly Ridge	11/7/03	0.02	<0.1	0.91	0.05	0.08	10
	11/14/03	0.21	0.33	0.6	0.03	0.06	2
	12/1/03	<0.01	<0.1	0.27	0.01	0.02	12
Oliver Street	12/1/03	0.14	0.17	0.11	0.05	0.1	1
Pine Street	11/7/03	0.2	<0.1	0.45	0.3	0.32	1
	11/14/03	0.27	<0.1	0.53	0.2	0.43	1
	12/1/03	0.14	<0.1	0.22	0.23	1.07	1
Robinson St.	11/7/03	0.24	<0.1	0.4	0.22	0.3	1
	11/14/03	0.6	0.4	0.84	0.25	0.31	1
	12/1/03	0.29	0.37	0.46	0.11	0.28	2

5.1.5 Pesticides

Water samples for the analysis of pesticides, including carbamate pesticides (Appendix 3), chlorinated organic pesticides (Appendix 4), phosphorus/nitrogen pesticides (Appendix 5), and chlorinated phenoxy acid herbicides (Appendix 6). No pesticides were found at or above detectable limits in any of the water samples.

5.1.6 Petroleum byproducts

Water samples were taken for the analyses of petroleum byproducts, including aromatic hydrocarbons (volatile organic compounds) (Appendix 7), polynuclear aromatic hydrocarbons (semi-volatile organic compounds) (Appendix 8), and volatile organic compounds in water (Appendix 9). No petroleum byproducts were found at or above detectable limits in any of the water samples.

5.1.7 Toxicity testing

5.1.7.1 Ceriodaphnia dubia

No survival toxicity of *Ceriodaphnia dubia* was detected at any of the storm drain monitoring locations sampled during the “first flush” event on November 7 (Table 5.1.7.1-1). However, the FRFBD, PSDRN and RSDRN samples exhibited reproductive toxicity (Table 5.1.7.1-2). Re-tests of these samples resulted in persistent reproductive toxicity.

In samples collected during the November 14 storm event, there was no survival toxicity detected in the storm drains, yet there was a significant reduction in survival from the river stations FRFBD, FRDFH, and FR162. Re-tests of these samples resulted in 100 percent survival of the test organisms. There was a significant reduction in reproduction in all samples except PSDRN. Re-tests confirmed persistent reproductive toxicity in these samples.

None of the December 1 samples exhibited survival toxicity, but all of the sample locations except KRDRN resulted in significant reductions in reproduction. Re-tests of the samples initially toxic confirmed persistent reproductive toxicity.

Table 5.1.7.1-1. Effects of Oroville drainage ambient water samples on survival of *Ceriodaphnia dubia*.

Treatment/ Sample ID	Survival (%)		
	11/07/03	**11/14/03**	**12/01/03**
Laboratory Control	100/100	90/100	100/100
Kelly Ridge Storm Drain (KRDRN)	90	100/100	90
Feather R A Oroville (FRFBD)	100/100	**50**/100	100
Feather R DS from Hatchery (FRDFH)	100	**0**/100	80
Oliver Street Storm Drain (OSDRN)	-	-	90/100
Pine Street Storm Drain (PSDRN)	100/100	100	90/90
Robinson Street Storm Drain (RSDRN)	90/100	100/100	100
Feather R at Highway 162 (FR162)	90	**40**/100	100

Bold = Significantly less than the control treatment at p<0.05.
Red = Re-test results

Table 5.1.7.1-2. Effects of Oroville drainage ambient water samples on reproduction in *Ceriodaphnia dubia*.

Treatment/ Sample ID	# neonates/female		
	11/07/03	**11/14/03**	**12/01/03**
Laboratory Control	32.3/36.1	26.6/36.1	31.8/21.1
Kelly Ridge Storm Drain (KRDRN)	32.3	**21.7/21.7**	29.6
Feather R A Oroville (FRFBD)	**24.8/25.7**	**5.6**/**26.8**	**25.6**
Feather R DS from Hatchery (FRDFH)	30.3	**0.1**/**14.9**	**11.6/7.2**
Oliver Street Storm Drain (OSDRN)	-	-	**13.8/12.3**
Pine Street Storm Drain (PSDRN)	**26.0/26.1**	26.3	**18.6/13.0**
Robinson Street Storm Drain (RSDRN)	**21.9/12.1**	**16.6/9.7**	**23.7**
Feather R at Highway 162 (FR162)	25.8	**2.0**/**23.5**	**25.4**

Bold = Significantly less than the control treatment at p<0.05.
Red = Re-test results

5.1.7.2 Larval Fathead Minnows

During the “first flush” event on November 7, there was a significant reduction in survival of larval fathead minnows at the FRFDH and FR162 locations (Table 5.1.7.2-1), but this was due to pathogen-related mortality (PRM). The occurrence of PRM in chronic fathead minnow toxicity tests of ambient or ponded waters is a common, confounding problem characterized by random mortalities resulting in high inter-replicate variability, and coverage of dead fish with a fungal “corona.”

PRM must be controlled in order to determine the toxicity of sample waters attributable to chemical contaminants. Fathead minnow water samples were tested by performing side-by-side analyses of unfiltered, and 0.45 micron filtered “splits” to distinguish between pathogen and contaminant related mortality as per USEPA guidelines. No significant reduction in survival was noted for the fathead minnow from the November 7 samples after the samples had been filtered to remove PRM (Table 5.1.7.2-2)

Growth endpoint (mean biomass) in the PSDRN and RSDRN samples from the November 7 storm event were significantly less than the control (Table 5.1.7.2-3). Filtration of these samples removed the reduced growth effect (Table 5.1.7.2-4).

Fathead minnow survival was significantly less than the control in the November 14 FRDFH sample, which was not due to PRM. PRM effects were exhibited in the FRFBD, RSDRN and FR162 samples. Filtration did not effectively remove PRM from the FRFBD and FR162 samples but was successful in eliminating the fungal corona in the RSDRN fish.

Fathead minnow growth was significantly less than the control in all of the November 14 samples except for the FRFDH and FR162 locations. No significant toxicity was exhibited in any of the filtered treatments.

Survival results for the December 1 samples were significantly reduced due to PRM in the samples from the drains servicing downtown Oroville. Results after filtration show the pathogens were effectively removed, although the initial testing of the filtered FRFBD sample resulted in a reduction in survival due to PRM. Re-testing of this sample effectively removed the pathogen resulting in improved fathead survival.

There was no significant reduction in fathead minnow growth in any of the December 1 samples. There was, however, a significant growth reduction in the filtered FRFBD and PSDRN samples.

Table 5.1.7.2-1. Effects of Oroville drainage water samples on survival of Pimphales promela.

Treatment/ Sample ID	Survival (%)		
	11/07/03	11/14/03	12/01/03
Laboratory Control	100	100	96.7
Kelly Ridge Storm Drain (KRDRN)	93.3	96.7	100
Feather R A Oroville (FRFBD)	90	73.3[1]	70.0
Feather R DS from Hatchery (FRDFH)	**46.7[1]**	**90**	90
Oliver Street Storm Drain (OSDRN)			**63.3[1]**
Pine Street Storm Drain (PSDRN)	93.3	93.3	**76.7[1]**
Robinson Street Storm Drain (RSDRN)	93.3	76.7[1]	**56.7[1]**
Feather R at Highway 162 (FR162)	**66.7[1]**	73.3[1]	86.7

Bold = Significantly less than the Control treatment at $p<0.05$.
Red = Re-test results
[1] reduction in survival appears to be due to pathogen related mortality

Table 5.1.7.2-2. Effects of filtered Oroville drainage water samples on survival of *Pimphales promela*.

Treatment/ Sample ID	Survival (%)		
	11/07/03	11/14/03	12/01/03
Laboratory Control	96.7	96.7	96.7/100
Kelly Ridge Storm Drain (KRDRN)	100	73.3[1]	93.3
Feather R A Oroville (FRFBD)	100	**43.3[1]**	**26.7[1]**/86.7
Feather R DS from Hatchery (FRDFH)	96.7	73.3[1]	100
Oliver Street Storm Drain (OSDRN)	-	-	83.3
Pine Street Storm Drain (PSDRN)	100	96.7	93.3
Robinson Street Storm Drain (RSDRN)	90	96.7	93.3
Feather R at Highway 162 (FR162)	100	63.3[1]	83.3

Bold = Significantly less than the Control treatment at $p<0.05$.
Red = Re-test results
[1] reduction in survival appears to be due to pathogen related mortality

Table 5.1.7.2-3. Effects of Oroville drainage water samples on growth of *Pimphales promela*.

	Biomass (mg)		
Treatment/ Sample ID	**11/07/03**	**11/14/03**	**12/01/03**
Laboratory Control	0.58	0.47	0.40
Kelly Ridge Storm Drain (KRDRN)	0.57	**0.40**	0.43
Feather R A Oroville (FRFBD)	0.51	**0.27**	0.29
Feather R DS from Hatchery (FRDFH)	0.33	0.35	0.37
Oliver Street Storm Drain (OSDRN)	-	-	0.20
Pine Street Storm Drain (PSDRN)	**0.42**	**0.26**	0.33
Robinson Street Storm Drain (RSDRN)	**0.41**	**0.30**	0.29
Feather R at Highway 162 (FR162)	0.48	0.30	0.36

Bold = Significantly less than the Control treatment at $p<0.05$.
Red = Re-test results

Table 5.1.7.2-4. Effects of filtered Oroville drainage water samples on growth of *Pimphales promela*.

	Biomass (mg)		
Treatment/ Sample ID	**11/07/03**	**11/14/03**	**12/01/03**
Laboratory Control	0.49	0.36	0.32/0.48
Kelly Ridge Storm Drain (KRDRN)	0.54	0.28	0.41
Feather R A Oroville (FRFBD)	0.44	0.18	0.13/**0.39**
Feather R DS from Hatchery (FRDFH)	0.45	0.30	0.37
Oliver Street Storm Drain (OSDRN)			0.33
Pine Street Storm Drain (PSDRN)	0.46	0.39	**0.23**
Robinson Street Storm Drain (RSDRN)	0.48	0.43	0.28
Feather R at Highway 162 (FR162)	0.41	0.21	0.36

Bold = Significantly less than the Control treatment at $p<0.05$.
Red = Re-test results

5.2 PESTICIDE TREATMENT SAMPLING

Water samples were collected monthly from May 2003 to November 2003 for analyses of methoprene and malathion. Water samples were obtainable from most of the ponds throughout the sampling period, but sampling grew increasingly difficult as the season progressed. Pond OWA-2 did not persist and dried up soon after the first sampling visit. Pond depths slowly decreased throughout the sampling period until physical parameter profiles became impossible to perform at some of the ponds. All of the ponds were heavily vegetated with submerged aquatic plants, and as the season progressed, some became increasingly covered with algae and mosquito fern (*Azolla* sp.).

5.2.1 Physical parameters

Physical parameters, including water temperature, dissolved oxygen, pH, and conductivity, were measured in all of the sampled ponds at the time of sampling (Appendix 10). Temperature and dissolved oxygen were measured at the surface and at every meter where possible. In addition, water temperature was measured at three sites along the Feather River within the OWA.

Stratification appeared to be fairly weak in the ponds, except for the deeper ones like Pond #5 (Figure 5.2.1-1) which normally reached three meters in depth. In slightly shallower ponds, like Pond #6, surface to bottom temperatures tended to be within two to three degrees Fahrenheit (Figure 5.2.1-2). Temperatures at the surface were rarely different from the temperatures at the lower depths in most of the ponds.

Even though temperature stratification was weak among the ponds, dissolved oxygen levels could decrease dramatically below one meter in depth. Some of the shallower ponds, such as Pond #3, had extremely low dissolved oxygen levels (below 3.0 mg/L) at the surface during the entire period of sampling (Figure 5.2.1-3). This pond was never deeper than one meter and usually remained at 0.5 meters in depth. It was also completely covered with algae and mosquito fern (Figure 4.2.2-4).

The deeper ponds showed some stratification of dissolved oxygen, though not very consistently (Figure 5.2.1-4). Pond #5 (Mile Long Pond) reached 3 meters in depth, with dissolved oxygen levels once measuring below 1.0 mg/L at the bottom. On occasion, the 1-meter dissolved oxygen measurements would be higher than the surface dissolved oxygen measurements, indicating that processes other than simple stratification were influencing dissolved oxygen levels. The 2- and 3-meter measurements tended to track fairly closely together, usually within two to three mg/L during the summer months.

pH and conductivity were measured at the surface of each sampling site (Appendix 8-10). There was some variability in pH, ranging from 6.8 to 8.5. Conductivity was very variable among all of the stations (Figure 5.2.1-5), especially ponds 5 and 6. The conductivity values from pond 5 ranged from 90 to 480 µmhos/cm, while conductivity in pond 6 ranged from 5 to 498 µmhos/cm. Stratification was not evident with conductivity.

Water temperature was measured at three sites along the Feather River opposite OWA pond #4, which is known as Robinsons Riffle Pond (Figure 4.2.2-10). Temperature measurements were taken at these sites to determine if seepage from the ponds in the OWA was reaching the Feather River. Site #1 was slightly upstream, site #2 was midway, and site #3 was slightly downstream from the pond. The water temperatures from the bottom depth of pond #4 were compared to the river water temperatures (Appendix 11), as it is assumed that seepage from the pond would be through the lower gravels of the pond. There seems to be no direct correlation between pond water temperatures and river water temperatures (Table 5.2.1-1; Figure 5.2.1-6).

Figure 5.2.1-1. Temperature profile at Pond #5 (Mile Long Pond) from May to November 2003.

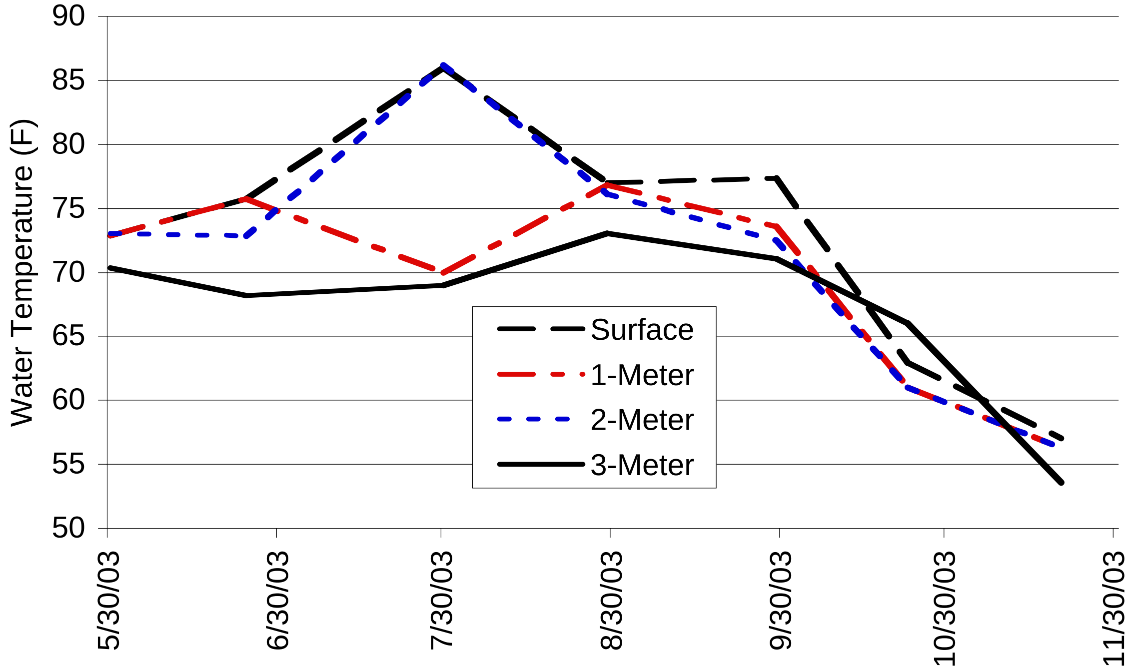


Figure 5.2.1-2. Temperature profile at Pond #6 from May to November 2003.

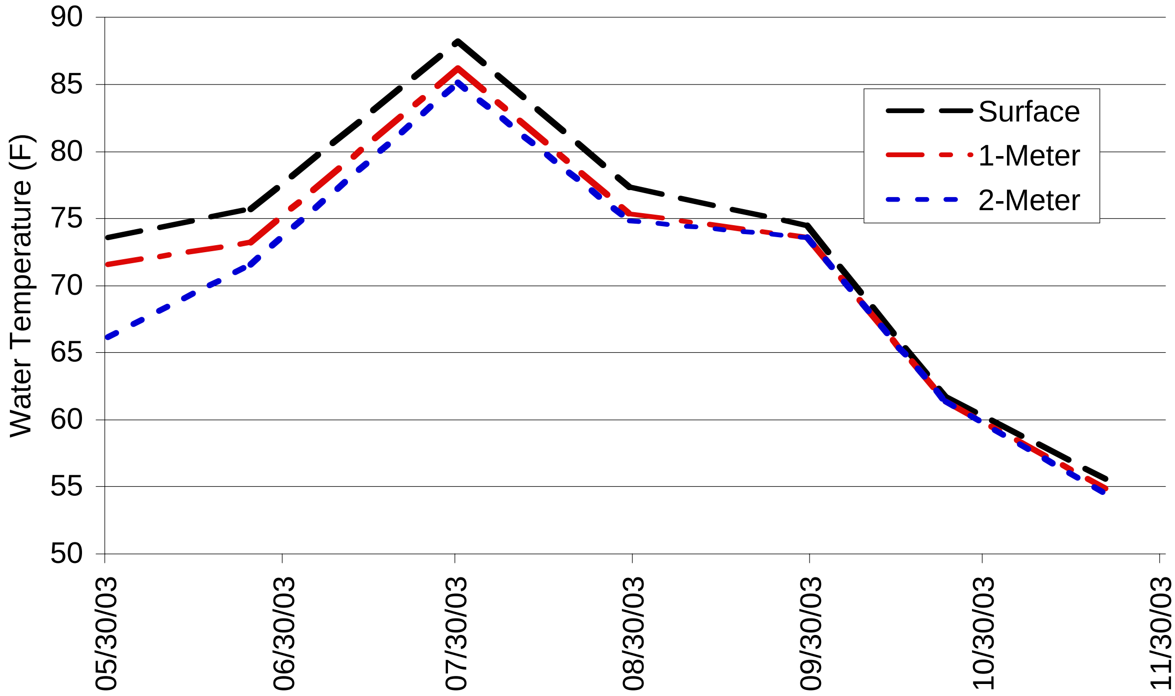


Figure 5.2.1-3. Dissolved oxygen levels in OWA pond #3 from May to November 2003.

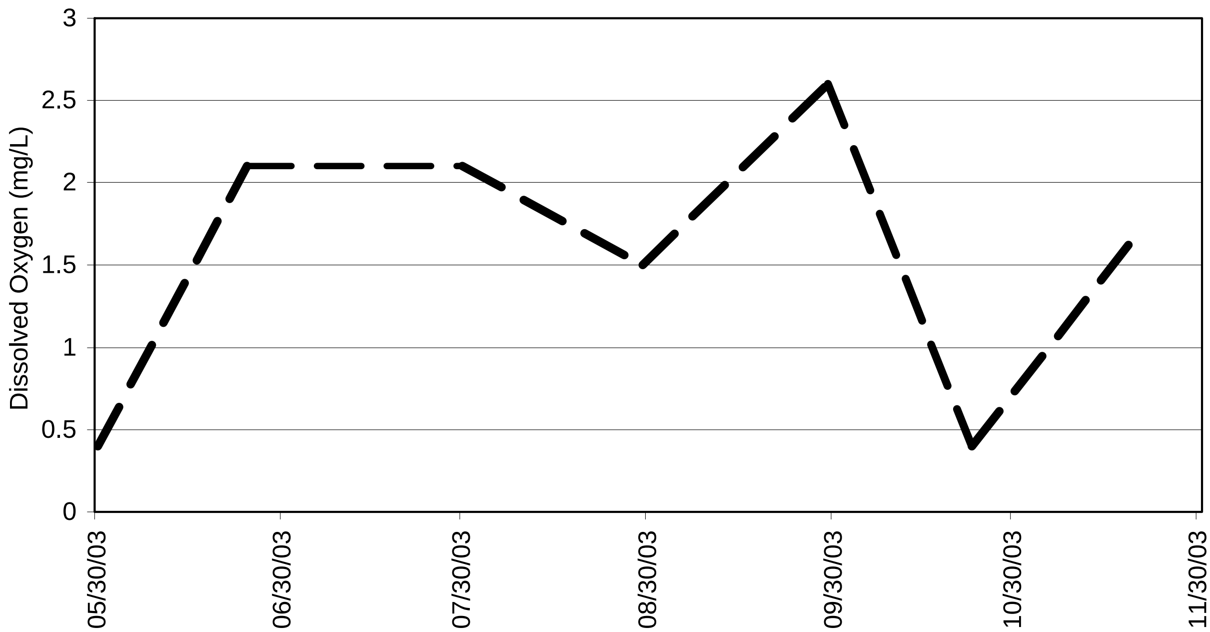


Figure 5.2.1-4. Dissolved oxygen profiles in OWA pond #5 from May to November 2003.

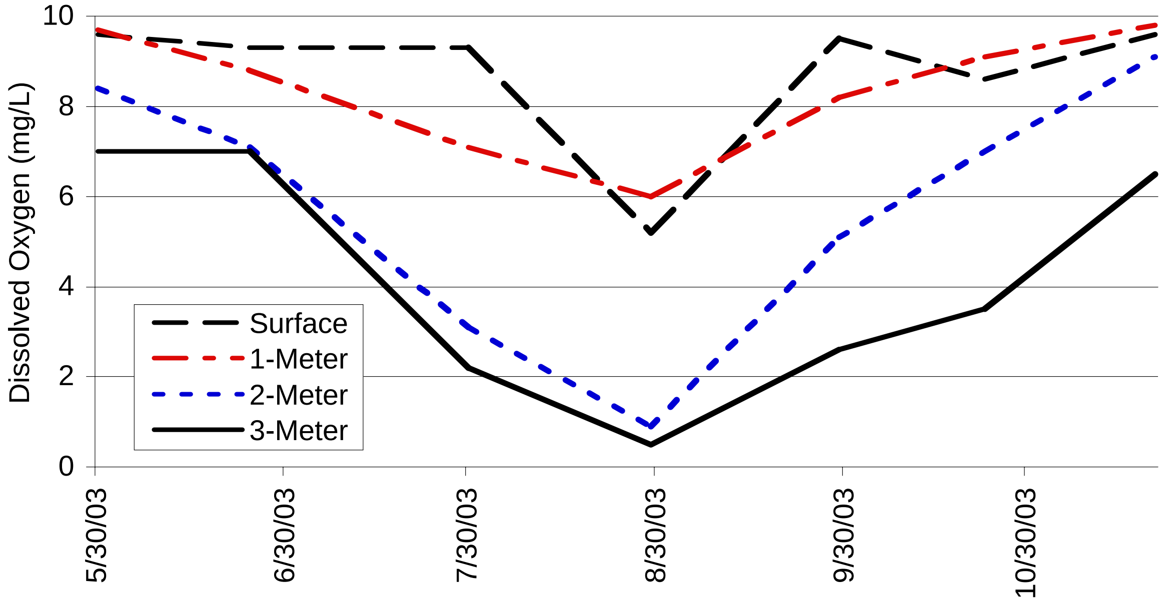


Figure 5.2.1-5. Conductivity values measured at the surface of all ponds from May to November 2003.

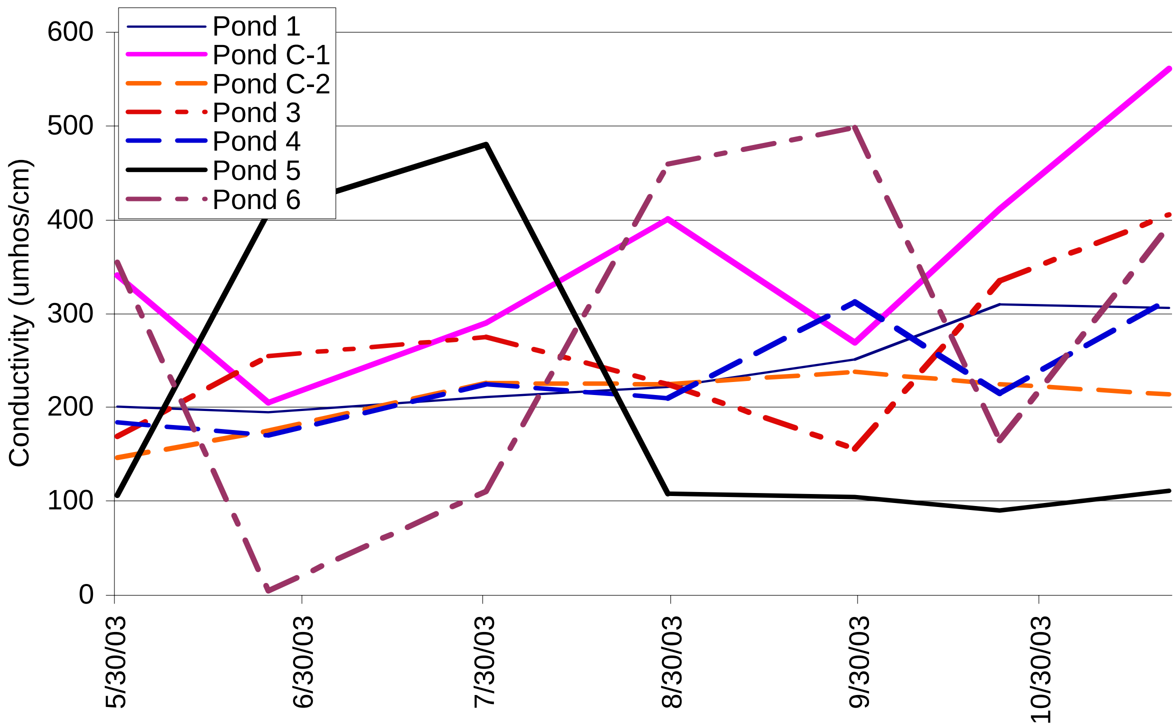
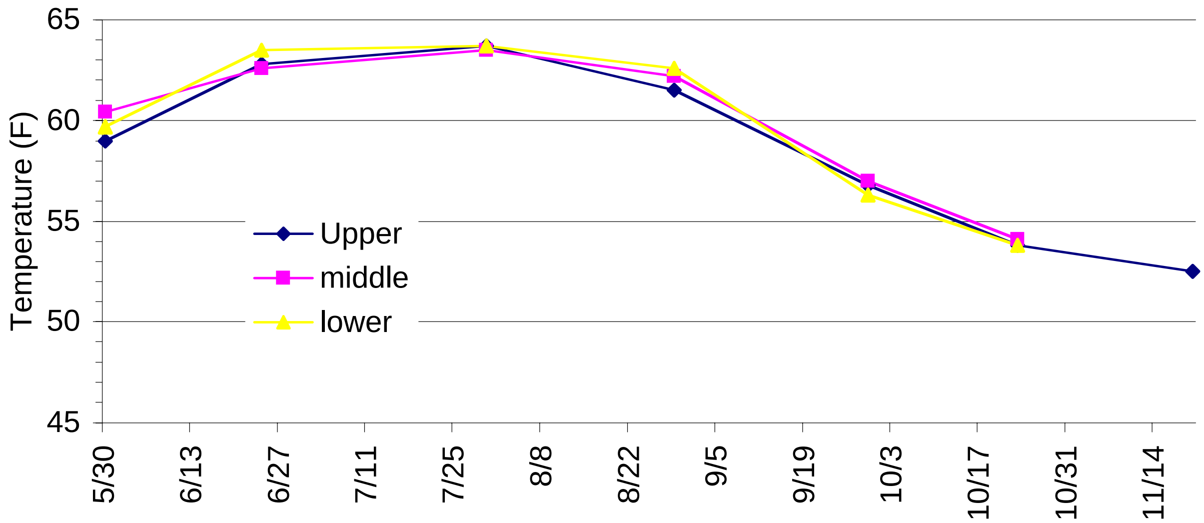


Table 5.2.1-1. Comparison of Feather River and OWA Pond #4 water temperatures.

		Feather River Temperature		OWA Pond #4 Temperature	
Station	Date	(°F)	(°C)	(°F)	(°C)
FR #1	5/30/03	59.0	15.0	64.2	17.9
	6/24/03	62.8	17.1	73.2	22.9
	7/30/03	63.7	17.6	79.5	26.4
	8/29/03	61.5	16.4	70.5	21.4
	9/29/03	56.8	13.8	64.6	18.1
	10/23/03	53.8	12.1	63.0	17.2
	11/20/03	52.5	11.4	53.1	11.7
FR #2	5/30/03	60.4	15.8	64.2	17.9
	6/24/03	62.6	17.0	73.2	22.9
	7/30/03	63.5	17.5	79.5	26.4
	8/29/03	62.2	16.8	70.5	21.4
	9/29/03	57.0	13.9	64.6	18.1
	10/23/03	54.1	12.3	63.0	17.2
FR #3	5/30/03	59.7	15.4	64.2	17.9
	6/24/03	63.5	17.5	73.2	22.9
	7/30/03	63.7	17.6	79.5	26.4
	8/29/03	62.6	17.0	70.5	21.4
	9/29/03	56.3	13.5	64.6	18.1
	10/23/03	53.8	12.1	63.0	17.2

Figure 5.2.1-6. Temperature comparison of the Feather River near OWA Pond #4.



5.2.2 Methoprene and Malathion

A total of 71 analytes and byproducts of methoprene and malathion were tested for in the water samples (Appendix 8-12). None of these analytes or byproducts was detected in the water samples taken during this study.

6.0 ANALYSES

6.1 EXISTING CONDITIONS/ENVIRONMENTAL SETTING

The purpose of this study was to determine any effects to water quality from land use and watershed activities at Lake Oroville, the Thermalito Afterbay and Forebay, and the lower Feather River. To address the issue of land use point source contamination, site-specific water quality sampling was performed at several storm drains within the urbanized area of the City of Oroville in November and December 2003. To assess potential non-point source contamination from a specific land-use activity, water quality sampling was performed in eight ponds within the Oroville Wildlife Area.

6.1.1 Stormwater Sampling

Four storm drains were sampled at the start of the rainy season in November and December of 2003. Three storm drains were within the City of Oroville and one was in the Kelly Ridge area. The drains were sampled for bacteria, metals, minerals, nutrients, petroleum byproducts, pesticides, and toxicity analyses. Additionally, three Feather River stations were sampled at the same time for toxicity analyses only.

6.1.2 Pesticide Treatment Sampling

Within the Oroville Wildlife Area, eight ponds (six experimental and two control ponds) were sampled to assess the potential contamination from the mosquito and vector control activities from the Butte County Mosquito and Vector Control District, which sprays the ponds in the OWA with methoprene and malathion (James Camy, pers. comm., 2003). The water samples were tested for a total of 71 byproducts and congeners of methoprene and malathion. Sampling started in May 2003 and ended in November 2003.

6.2 PROJECT RELATED EFFECTS

There is a wide variety of land-use and watershed activities within and adjacent to Project facilities, as reported in the SP-W7 Task 1A report. Most of the Project and adjacent lands are monitored for water quality in SP-W1, so only limited water quality sampling was proposed in the Task 1A report. Water quality sampling in this study was performed for only those activities or land-uses not adequately covered by SP-W1.

Results of water quality sampling for this study were evaluated for potential effects to water quality from Project-related and adjacent land-use activities.

6.2.1 Stormwater Sampling

Urbanized land-use effects to water quality were assessed through storm water sampling. These drains empty directly into Project waters and could be affecting water quality. The three drains within the City of Oroville and the drain at Kelly Ridge all showed high levels of total and fecal coliform, enterococcus, and fecal streptococcus bacteria, some of which were at times present in numbers higher than the maximum that could be identified with the bacteria analysis technique (denoted as >1600 colonies/100 mL). The SP-W1 study has found that the Feather River can occasionally exceed the criteria for fecal coliform bacteria. The swim area at Bedrock Park on the Feather River reached a maximum of 300 colonies/100 mL for enterococcus and fecal coliform bacteria, which were still well under the levels seen in the storm drain samples.

Some metals in the storm drain samples, notably aluminum, arsenic, iron, manganese, and zinc, exceeded various criteria. All of the metals but zinc were found at or below the background levels found in SP-W1 and SP-W3 sampling. Zinc, however, was well above the background level. Several factors, such as water hardness, salinity, temperature, and the presence of other contaminants, influence zinc toxicity in aquatic environments. Elevated concentrations of zinc in water are particularly toxic to many species of algae, crustaceans, and salmonids. Zinc toxicity can have especially strong impacts on aquatic macroinvertebrates such as molluscs, crustaceans, odonates, and ephemeropterans (Irwin et al. 1997). The elevated zinc levels found in the storm runoff samples could potentially affect the water quality of the Feather River.

Petroleum byproducts and pesticides were below detection levels. An unpredicted rainstorm occurred in late October, which may have influenced the results by mobilizing and flushing petroleum byproducts and pesticides residues.

6.1.2 Pesticide Treatment Sampling

Methoprene and malathion, or any of the byproducts of the two, were below detection levels throughout this study. Pesticide treatment of the OWA ponds was on-going throughout the sampling period, so treatment events were not missed.

Methoprene breaks down in less than two days on contact with water (Ross *et al*., 1994), with little or no effect on non-target species (Batzer and Sjogren, 1986; Brown *et al*., 1999; Miura and Takahashi, 1973). Methoprene has a half-life in pond water of about 30 and 40 hours at initial concentrations of 0.001 and 0.01 mg/L, respectively. At normal temperatures and levels of sunlight, methoprene is rapidly degraded, mainly by aquatic microorganisms and sunlight (Extension Toxicology Network, 1996a).

Malathion is applied as an ultra-low volume spray. Ultra-low volume sprayers dispense very fine aerosol droplets that stay aloft and kill mosquitoes on contact (USEPA, 2003). Malathion degrades rapidly in the environment, especially when applied as aerosol droplets. If released to the atmosphere, malathion will break down rapidly in sunlight, with a reported half-life in air of about 1.5 days (Extension Toxicology Network, 1996b). Malathion is soluble in water. If malathion is washed from the air or from foliage by a sudden rain or is accidentally applied to water, it can remain stable for 2.5 to 6 weeks. This could pose a risk of groundwater or surface water contamination. The compound has been detected in small concentrations in several wells in California, with a highest concentration of 6.17µg/L (Extension Toxicology Network, 1996b). The malathion spraying within the Oroville Wildlife Area is targeted at flying adult mosquitoes in foliage, and is applied in aerosol form and is not directly applied to waters (James Camy, pers. comm., 2003).

Therefore, there is no apparent effect to water quality from the treatment of the ponds with methoprene and malathion.

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8.0 APPENDICES

Appendix 1. Stormwater sampling - Dissolved metals.

Station	Date	Dissolved Aluminum (µg/L)	Dissolved Arsenic (µg/L)	Dissolved Cadmium (µg/L)	Dissolved Chromium (µg/L)	Dissolved Copper (µg/L)	Dissolved Iron (µg/L)
Kelly Ridge	11/07/03	71.8	0.526	<0.016	<0.039	2.04	131
	11/14/03	302	0.59	<0.016	1.3	2.78	362
	12/01/03	25.6	0.542	<0.009	0.92	0.93	77.9
Oliver Street	12/01/03	52.5	0.248	0.049	0.55	1.81	44.9
Pine Street	11/07/03	17.9	0.434	<0.016	<0.039	4.4	47
	11/14/03	65	0.27	<0.016	0.51	6.64	91
	12/01/03	95.8	0.459	0.032	0.85	3.49	298
Robinson St.	11/07/03	39.3	0.449	<0.016	<0.039	3.8	50.5
	11/14/03	118	0.6	<0.016	0.4	4.68	136
	12/01/03	40.7	0.609	0.026	0.85	1.79	123

Appendix 1. Continued.

Station	Date	Dissolved Lead (µg/L)	Dissolved Manganese (µg/L)	Dissolved Nickel (µg/L)	Dissolved Selenium (µg/L)	Dissolved Silver (µg/L)	Dissolved Zinc (µg/L)
Kelly Ridge	11/07/03	0.056	2.2	1.43	<0.232	0.067	2.71
	11/14/03	0.322	4.39	1.36	<0.232	<0.012	4.17
	12/01/03	0.024	9.73	1.37	0.2	<0.018	2.31
Oliver Street	12/01/03	2.55	5.45	0.87	<0.119	<0.018	38.4
Pine Street	11/07/03	0.662	2.68	1.31	<0.232	0.172	27.3
	11/14/03	2.19	21	1.84	0.25	<0.012	39.8
	12/01/03	4	32.7	1.71	<0.119	0.122	58.1
Robinson Street	11/07/03	0.671	3.55	1.18	<0.232	0.17	33.7
	11/14/03	2.06	22.7	1.62	<0.232	<0.012	37.3
	12/01/03	1.51	34.1	2.05	<0.119	0.087	63.5

Appendix 2. Stormwater sampling - Total metals.

Station	Date	Total Aluminum (µg/L)	Total Arsenic (µg/L)	Total Cadmium (µg/L)	Total Chromium (µg/L)	Total Copper (µg/L)	Total Iron (µg/L)
Kelly Ridge	11/07/03	71.8	0.603	<0.023	0.87	2.75	213
	11/14/03	462	0.71	<0.023	3.03	5.38	811
	12/01/03	30.4	0.554	0.015	0.92	1.41	140
Pine Street	11/07/03	130	0.499	<0.023	1.01	6.43	205
	11/14/03	135	0.588	<0.023	0.823	7.36	222
	12/01/03	580	0.566	0.221	2.65	9.93	1009
Robinson Street	11/07/03	114	0.509	<0.023	0.74	5.52	178
	11/14/03	322	0.629	<0.023	1.23	7.5	501
	12/01/03	595	0.694	0.188	2.63	8.83	933

Appendix 2. Continued.

Station	Date	Total Lead (µg/L)	Total Manganese (µg/L)	Total Nickel (µg/L)	Total Selenium (µg/L)	Total Silver (µg/L)	Total Zinc (µg/L)
Kelly Ridge	11/07/03	0.136	63.5	1.68	0.26	0.11	5.26
	11/14/03	1.03	60.8	2.91	0.12	<0.006	11.6
	12/01/03	0.04	77.2	1.48	0.26	0.093	4.32
Pine Street	11/07/03	2.72	14	1.89	0.14	0.242	33.6
	11/14/03	3.51	21	2.32	0.253	<0.006	43.9
	12/01/03	21.9	43.5	4.21	0.11	0.224	89.2
Robinson Street	11/07/03	2	12.2	1.77	0.16	0.231	41.1
	11/14/03	6.48	26.8	3.16	0.182	<0.006	49.1
	12/01/03	10.9	42	4.58	0.08	0.182	85.3

Appendix 3. Stormwater sampling - Carbamate pesticides.

Analyte	Detection Limit (µg/L)	Analyte	Detection Limit (µg/L)
3-Hydroxycarbofuran	<2	Formetanate hydrochloride	<100
Aldicarb	<2	Methiocarb	<4
Aldicarb sulfone	<2	Methomyl	<2
Aldicarb sulfoxide	<2	Oxamyl	<2
Carbaryl	<2	Glyphosate	<25
Carbofuran	<2		

Appendix 4. Stormwater sampling - Chlorinated organic pesticides.

Analyte	Detection Limit (µg/L)	Analyte	Detection Limit (µg/L)
Alachlor	<0.05	Endrin aldehyde	<0.01
Aldrin	<0.01	Heptachlor	<0.01
Atrazine	<0.02	Heptachlor epoxide	<0.01
BHC-alpha	<0.01	Methoxychlor	<0.05
BHC-beta	<0.01	Metolachlor	<0.05
BHC-delta	<0.01	o,p'-DDE	<0.01
BHC-gamma (Lindane)	<0.01	Oxyfluorfen	<0.1
Captan	<0.05	p,p'-DDD	<0.01
Chlordane	<0.05	p,p'-DDE	<0.01
Chlorothalonil	<0.01	p,p'-DDT	<0.05
Chlorpropham	<0.02	PCB-1016	<0.1
Chlorpyrifos	<0.01	PCB-1221	<0.1
Cyanizine	<0.1	PCB-1232	<0.1
Dacthal (DCPA)	<0.01	PCB-1242	<0.1
Dichloran	<0.01	PCB-1248	<0.1
Dicofol	<0.05	PCB-1254	<0.1
Dieldrin	<0.01	PCB-1260	<0.1
Diuron	<0.25	PCNB	<0.01
Endosulfan sulfate	<0.02	Permethrin	<0.02
Endosulfan-I	<0.01	Simazine	<0.02
Endosulfan-II	<0.01	Thiobencarb	<0.02
Endrin	<0.01	Toxaphene	<0.4

Appendix 5. Stormwater sampling - Phosphorus/nitrogen pesticides.

Analyte	Detection Limit (µg/L)	Analyte	Detection Limit (µg/L)
Azinphos methyl (Guthion)	<0.05	Naled	<0.02
Benflurin	<0.01	Napropamide	<0.05
Bromacil	<0.1	Norflurazon	<0.05
Carbophenothion (Trithion)	<0.02	Parathion (Ethyl)	<0.01
Chlorpyrifos	<0.01	Parathion (Methyl)	<0.01
Cyanazine	<0.1	Pendimethalin	<0.05
Demeton (O +S)	<0.1	Phorate	<0.01
Diazinon	<0.01	Phosalone	<0.02
Dimethoate	<0.01	Phosmet	<0.02
Disulfoton	<0.1	Profenofos	<0.01
Esfenvalerate	<0.02	Prometryn	<0.05
Ethion	<0.01	Propetamphos	<0.1
Malathion	<0.02	s,s,s-Tributyl Phosphorotrithioate	<0.01
Methidathion	<0.02	Thiobencarb	<0.02
Mevinphos	<0.01	Trifluralin	<0.01
Molinate	<0.02		

Appendix 6. Stormwater sampling - Chlorinated phenoxy acid herbicides.

Analyte	Detection Limit (µg/L)	Analyte	Detection Limit (µg/L)
2,4,5-T	<0.1	Dinoseb (DNPB)	<0.1
2,4,5-TP (Silvex)	<0.1	MCPA	<0.1
2,4-D	<0.1	MCCP	<0.1
2,4-DB	<0.1	Pentachlorophenol (PCP)	<0.1
Dacthal (DCPA)	<0.1	Picloram	<0.1
Dicamba	<0.1	Triclopyr	<0.1
Dichloroprop	<0.1		

Appendix 7. Stormwater sampling - Aromatic hydrocarbons (Volatile organic compounds).

Analyte	Detection Limit (µg/L)	Analyte	Detection Limit (µg/L)
Benzene	<0.5	1,2-Dichloropropane	<0.5
Bromobenzene	<0.5	1,3-Dichloropropane	<0.5
Bromochloromethane	<0.5	2,2-Dichloropropane	<0.5
Bromoform	<0.5	1,1-Dichloropropene	<0.5
Bromomethane	<1.0	Ethylbenzene	<0.5
n-Butylbenzene	<0.5	Hexachlorobutadiene	<1.0
sec-Butylbenzene	<0.5	Isopropylbenzene	<0.5
tert-Butylbenzene	<0.5	p-Isopropyltoluene	<0.5
Carbon tetrachloride	<0.5	Methylene chloride	<1.0
Chlorobenzene	<0.5	Methyl tert-butyl ether	<0.5
Chlrorethane	<0.5	Naphthalene	<1.0
Chloroform	<0.5	n-Propylbenzene	<0.5
Chlrormethane	<0.5	Styrene	<0.5
2-Chlorotoluene	<0.5	1,1,1,2-Tetrachloroethane	<0.5
4-Chlorotoluene	<0.5	1,1,2,2-Tetrachloroethane	<1.0
Dibromochloromethane	<0.5	Tetrachloroethane	<0.5
1,2-Dibromoethane	<0.5	Toluene	<0.5
Dibromomethane	<0.5	1,2,3-Trichlorobenzene	<0.5
1,2-Dibromo-3-chloropropane	<1.0	1,2,4-Trichlorobenzene	<0.5
1,2-Dichlorobenzene	<0.5	1,1,1-Trichloroethane	<0.5
1,3-Dichlorobenzene	<0.5	1,1,2-Trichloroethane	<0.5
1,4-Dichlorobenzene	<0.5	Trichlorofluoromethane	<0.5
Dichlorodifluoromethane	<0.5	1,2,3-Trichloropropane	<1.0
1,1-Dichloroethane	<0.5	1,2,4-Trimethylbenzene	<0.5
1,2-Dichloroethane	<0.5	1,3,5-Trimethylbenzene	<0.5
1,1-Dichloroethene	<0.5	Vinyl chloride	<0.5
cis-1,2-Dichloroethene	<0.5	Xylenes (total)	<0.5
trans-1,2-Dichloroethene	<0.5		

Appendix 8. Stormwater sampling - Polynuclear aromatic hydrocarbons (Semi-volatile organic compounds).

Analyte	Detection Limit (µg/L)	Analyte	Detection Limit (µg/L)
Acenaphthene	<5	Dibenz (a,h) anthracene	<5
Acenaphthylene	<5	Fluoranthene	<5
Anthracene	<5	Fluorene	<5
Benzo (a) anthracene	<5	Indeno (1,2,3-cd) pyrene	<5
Benzo (a) pyrene	<5	Naphthalene	<10

Appendix 9. Stormwater sampling - Volatile organic compounds in water.

Analyte	Detection Limit (µg/L)	Analyte	Detection Limit (µg/L)
1,1,1,2-Tetrachloroethane	<0.5	Carbon tetrachloride	<0.5
1,1,1-Trichloroethane	<0.5	Chlorobenzene	<0.5
1,1,2,2-Tetrachloroethane	<0.5	Chloroethane	<0.5
1,1,2-Trichloroethane	<0.5	Chloroform	<0.5
1,1-Dichloroethane	<0.5	Chloromethane	<0.5
1,1-Dichloroethene	<0.5	cis-1,2-Dichloroethene	<0.5
1,1-Dichloropropene	<0.5	cis-1,3-Dichloropropene	<0.5
1,2,3-Trichlorobenzene	<0.5	Dibromochloromethane	<0.5
1,2,3-Trichloropropane	<0.5	Dibromomethane	<0.5
1,2,4-Trichlorobenzene	<0.5	Dichlorodifluoromethane	<0.5
1,2,4-Trimethylbenzene	<0.5	Ethyl benzene	<0.5
1,2-Dibromo-3-chloropropane	<0.5	Hexachlorobutadiene	<0.5
1,2-Dibromoethane	<0.5	Isopropylbenzene	<0.5
1,2-Dichlorobenzene	<0.5	m+p Xylene	<0.5
1,2-Dichloroethane	<0.5	Methyl tert-butyl ether	<1.0
1,2-Dichloropropane	<0.5	Methylene chloride	<0.5
1,3,5-Trimethylbenzene	<0.5	n-Butylbenzene	<0.5
1,3-Dichlorobenzene	<0.5	n-Propylbenzene	<0.5
1,3-Dichloropropane	<0.5	Naphthalene	<0.5
1,4-Dichlorobenzene	<0.5	o-Xylene	<0.5
2,2-Dichloropropane	<0.5	sec-Butylbenzene	<0.5
2-Chlorotoluene	<0.5	Styrene	<0.5
4-Chlorotoluene	<0.5	tert-Butylbenzene	<0.5

Analyte	Detection Limit (µg/L)	Analyte	Detection Limit (µg/L)
4-Isopropyltoluene	<0.5	Tetrachloroethene	<0.5
Benzene	<0.5	Toluene	<0.5
Bromobenzene	<0.5	trans-1,2-Dichloroethene	<0.5
Bromochloromethane	<0.5	trans-1,3-Dichloropropene	<0.5
Bromodichloromethane	<0.5	Trichloroethene	<0.5
Bromoform	<0.5	Trichlorofluorene	<0.5
Bromomethane	<0.5	Vinyl chloride	<0.5

Appendix 10. Pesticide sampling – Physical parameters.

Station	Date	Depth (m)	Temperature (°F)	Temperature (°C)	Dissolved Oxygen (mg/L)	pH	Conductivity (µmhos/cm)
Pond 1	5/30/03	Sfc	72.68	22.6	5.1	7.7	201
		1	73.04	22.8	4.5		
		1.5	65.48	18.6	1.9		
	6/24/03	Sfc	73.94	23.3	4.6	8.4	195
		1	71.6	22	2.1		
	7/30/03	Sfc	89.6	32	2.7	7.2	211
		1	87.98	31.1	2.3		
	8/29/03	Sfc	76.28	24.6	6.9	8.4	222
		1	71.42	21.9	0.5		
	9/29/03	Sfc	71.6	22	9.3	7.7	251
		1	66.92	19.4	1.0		
	10/23/03	Sfc	66.92	19.4	12	7.2	310
		1	68.18	20.1	4.2		
	11/20/03	Sfc	59	15	4.9	6.8	306
		1	59.38	15.1	2.1		
Control 1	5/30/03	Sfc	75.2	24	2.2	6.9	341
		1	69.8	21	1.1		
	6/24/03	Sfc	78.26	25.7	5.1	7.9	205
		1	73.76	23.2	2.2		
	7/30/03	Sfc	88.34	31.3	3.2	8.4	290
		1	87.44	30.8	2.5		
	8/29/03	Sfc	83.3	28.5	15.1	8.5	401
		1	82.58	28.1	3.1		
		1.5	82.22	27.9	0.9		
	9/29/03	Sfc	71.06	21.7	8.1	8	269
		1	68.18	20.1	1.2		
	10/23/03	Sfc	68.18	20.1	10.5	7.6	412
		1	68	20.0	5.1		
	11/20/03	Sfc	58.46	14.7	7.2	7	561
Pond 2	5/30/03	Sfc	67.1	19.5	1.2	7.1	288
		1	67.1	19.5	1.1		
Control 2	5/30/03	Sfc	73.4	23.0	6.9	8.1	146
		1	73.22	22.9	7.0		
		2	72.5	22.5	5.5		
		3	69.26	20.7	1.2		
		3.5	69.08	20.6	0.8		
	6/24/03	Sfc	77.2	25.1	4.6	7.6	175
		1	76.8	24.9	5.1		
		2	73.6	23.1	4.0		

Station	Date	Depth (m)	Temperature (^oF)	(^oC)	Dissolved Oxygen (mg/L)	pH	Conductivity (μmhos/cm)
		3	73.4	23.0	2.1		
	7/30/03	Sfc	87.3	30.7	2.1	7.2	226
		1	85.8	29.9	3.0		
		2	85.6	29.8	2.0		
		3	80.8	27.1	1.6		
	8/29/03	Sfc	82.0	27.8	3.6	7.3	225
		1	79.5	26.4	1.8		
		2	79.5	26.4	0.6		
		2.5	80.2	26.8	0.4		
	9/29/03	Sfc	71.8	22.1	4.7	7.8	238
		2	71.6	22.0	2.1		
		1.5	70.7	21.5	1.0		
	10/23/03	Sfc	68.9	20.5	11.5	7.8	225
		1	62.8	17.1	9.1		
	11/20/03	Sfc	58.1	14.5	11.1	7.6	214
		1	58.3	14.6	10.0		
Pond 3	5/30/03	Sfc	70.0	21.1	0.4	7.5	169
	6/24/03	Sfc	77.9	25.5	2.1	8.1	255
	7/30/03	Sfc	89.4	31.9	2.1	7.2	275
		1	86.9	30.5	2.0		
	8/29/03	Sfc	80.2	26.8	1.5	8.2	225
	9/29/03	Sfc	74.3	23.5	2.6	7.9	156
	10/23/03	Sfc	64.6	18.1	0.4	7.1	335
	11/20/03	Sfc	53.2	11.8	1.7	7.2	406
		1	52.0	11.1	0.7		
Pond 4	5/30/03	Sfc	83.1	28.4	4.1	7.5	184
		1	68.2	20.1	0.4		
		1.5	64.2	17.9	0.4		
	6/24/03	Sfc	78.6	25.9	5.0	8	170
		1	73.6	23.1	5.9		
		2	73.2	22.9	3.0		
	7/30/03	Sfc	79.3	26.3	2.9	7.4	225
		1	79.2	26.2	2.9		
		2	79.5	26.4	2.4		
	8/29/03	Sfc	77.5	25.3	3.1	8	210
		1	70.9	21.6	0.8		
		2	70.52	21.4	0.5		
	9/29/03	Sfc	65.8	18.8	4.1	7	312
		1	64.9	18.3	2.0		
		1.5	64.6	18.1	1.1		
	10/23/03	Sfc	61.9	16.6	3.6	7.6	215

Station	Date	Depth (m)	Temperature (^oF)	(^oC)	Dissolved Oxygen (mg/L)	pH	Conductivity (µmhos/cm)
		1	62.8	17.1	2.1		
		2	63.0	17.2	1.5		
	11/20/03	Sfc	53.2	11.8	1.5	7.2	315
		1	52.9	11.6	2.6		
		2	53.1	11.7	1.0		
Pond 5	5/30/03	Sfc	72.9	22.7	9.6	7.6	106
		1	72.9	22.7	9.7		
		2	73.0	22.8	8.4		
		3	70.3	21.3	7.0		
	6/24/03	Sfc	75.7	24.3	9.3	8.2	408
		1	75.7	24.3	8.8		
		2	72.9	22.7	7.1		
		3	68.2	20.1	7.0		
		3.5	66.6	19.2	5.1		
	7/30/03	Sfc	86.0	30.0	9.3	7.0	480
		1	70.0	21.1	7.1		
		2	86.2	30.1	3.1		
	8/29/03	Sfc	77.0	25.0	5.2	7.9	108
		1	76.8	24.9	6.0		
		2	76.1	24.5	0.9		
		3	73.0	22.8	0.5		
	9/29/03	Sfc	77.4	25.2	9.5	7.0	104
		1	73.6	23.1	8.2		
		2	72.5	22.5	5.1		
		2.5	71.1	21.7	2.6		
	10/23/03	Sfc	63.0	17.2	8.6	7.6	90
		1	61.0	16.1	9.1		
		2	61.0	16.1	7.0		
	11/20/03	Sfc	57.0	13.9	9.6	7.8	111
		1	56.3	13.5	9.8		
		2	56.3	13.5	9.1		
		2.5	53.6	12.0	6.5		
Pond 6	5/30/03	Sfc	73.6	23.1	6.1	8.1	355
		1	71.6	22.0	6.0		
		2	66.2	19.0	4.1		
	6/24/03	Sfc	75.7	24.3	5.0	8.2	4.8
		1	73.2	22.9	5.0		
		2	71.6	22.0	4.1		
	7/30/03	Sfc	88.2	31.2	9.4	7.4	110
		1	86.2	30.1	9.7		
		2	85.1	29.5	8.4		

Station	Date	Depth (m)	Temperature (°F)	(°C)	Dissolved Oxygen (mg/L)	pH	Conductivity (µmhos/cm)
		2.5	80.6	27.0	6.1		
	8/29/03	Sfc	77.4	25.2	1.5	8.1	459
		1	75.4	24.1	0.7		
		2	74.8	23.8	0.5		
	9/29/03	Sfc	74.5	23.6	9.2	7.6	498
		1	73.6	23.1	6.1		
		2	73.6	23.1	5.3		
	10/23/03	Sfc	61.7	16.5	7.6	7.4	165
		1	61.3	16.3	8.1		
		2	61.3	16.3	5.0		
	11/20/03	Sfc	55.6	13.1	9.6	7.8	394
		1	54.9	12.7	9.1		
		2	54.5	12.5	9.0		

Appendix 11. Pesticide sampling – Comparison of Feather River water temperatures with OWA pond #4

				OWA Pond #4		
		Temperature		Depth	Temperature	
Station	Date	(°F)	(°C)	(m)	(°F)	(°C)
FR #1	5/30/03	59.0	15.0	Sfc	83.12	28.4
				1	68.18	20.1
				1.5	64.22	17.9
	6/24/03	62.78	17.1	Sfc	78.62	25.9
				1	73.58	23.1
				2	73.22	22.9
	7/30/03	63.68	17.6	Sfc	79.34	26.3
				1	79.16	26.2
				2	79.52	26.4
	8/29/03	61.52	16.4	Sfc	77.54	25.3
				1	70.88	21.6
				2	70.52	21.4
	9/29/03	56.84	13.8	Sfc	65.84	18.8
				1	64.94	18.3
				1.5	64.58	18.1
	10/23/03	53.78	12.1	Sfc	61.88	16.6
				1	62.78	17.1
				1.5	62.96	17.2
	11/20/03	52.52	11.4	Sfc	53.24	11.8
				1	52.88	11.6
				2	53.06	11.7
FR #2	5/30/03	60.44	15.8	Sfc	83.12	28.4
				1	68.18	20.1
				1.5	64.22	17.9
	6/24/03	62.6	17.0	Sfc	78.62	25.9
				1	73.58	23.1
				2	73.22	22.9
	7/30/03	63.5	17.5	Sfc	79.34	26.3
				1	79.16	26.2
				2	79.52	26.4
	8/29/03	62.24	16.8	Sfc	77.54	25.3
				1	70.88	21.6
				2	70.52	21.4
	9/29/03	57.02	13.9	Sfc	65.84	18.8
				1	64.94	18.3
				1.5	64.58	18.1
	10/23/03	54.14	12.3	Sfc	61.88	16.6
				1	62.78	17.1

				1.5	62.96	17.2
FR #3	5/30/03	59.72	15.4	Sfc	83.12	28.4
				1	68.18	20.1
				1.5	64.22	17.9
	6/24/03	63.5	17.5	Sfc	78.62	25.9
				1	73.58	23.1
				2	73.22	22.9
	7/30/03	63.68	17.6	Sfc	79.34	26.3
				1	79.16	26.2
				2	79.52	26.4
	8/29/03	62.6	17.0	Sfc	77.54	25.3
				1	70.88	21.6
				2	70.52	21.4
	9/29/03	56.3	13.5	Sfc	65.84	18.8
				1	64.94	18.3
				1.5	64.58	18.1
	10/23/03	53.78	12.1	Sfc	61.88	16.6
				1	62.78	17.1
				1.5	62.96	17.2

Appendix 12. Pesticide sampling - Analytes

Analyte	Detection Limit (µg/L)	Analyte	Detection Limit (µg/L)
1,2,4-Trichlorobenzene	<5	Benzo (k) fluoranthene	<5
1,2-Dichlorobenzene	<5	Benzoic Acid	<20
1,3-Dichlorobenzene	<5	Benzyl Alcohol	<5
1,4-Dichlorobenzene	<5	Benzyl butylphthalate	<5
2,4,5-Trichlorophenol	<10	Bis(2-chloroethoxy)methane	<5
2,4,6-Trichlorophenol	<10	Bis(2-chloro-ethyl)ether	<5
2,4-Dichlorophenol	<10	Bis(2-chloropropyl)ether	<5
2,4-Dimethylphenol	<5	Bis(2-ethylhexyl) phthalate	<5
2,4-Dinitrophenol	<20	Carbazole	<5
2,4-Dinitrotoluene	<5	Chrysene	<5
2,6-Dinitrotoluene	<5	Dibenz (a,h) anthracene	<5
2-Chloronaphthalene	<5	Dibenzofuran	<5
2-Chlorophenol	<10	Diethylphthlate	<5
2-Methylnaphthalene	<5	Dimethylphthalate	<5
2-Methylphenol	<5	Di-n-butylphthalate	<5
2-Nitroaniline	<5	Di-n-octyl phthalate	<5
2-Nitrophenol	<20	Fluoranthene	<5
3,3'-Dichlorobenzidine	<10	Fluorene	<5
3-Nitroaniline	<5	Hexachlorobenzene	<5
4,6-Dinitro-2-methylphenol	<20	Hexachlorobutadiene	<5
4-Bromophenyl-phenylether	<5	Hexachlorocyclopentadiene	<20
4-Chloro-3-methylphenol	<5	Hexachloroethane	<5
4-Chloroaniline	<5	Indeno (1,2,3-cd) pyrene	<5
4-Chlorophenylphenylester	<5	Isophorone	<5
4-Methylphenol	<5	Malathion	<5
4-Nitroaniline	<5	Methoprene	<5
4-Nitrophenol	<20	Naphthalene	<10
Acenaphthene	<5	Nitrobenzene	<5
Acenaphthylene	<5	N-Nitrosodimethyamine	<5
Aniline	<5	N-Nitrosodi-n-propylamine	<5
Anthracene	<5	N-Nitrosodiphenylamine	<5
Azobenzene	<5	Pentalchlorophenol	<20
Benzo (a) anthracene	<5	Phenanthrene	<5
Benzo (a) pyrene	<5	Phenol	<5
Benzo (b) fluoranthene	<5	Pyrene	<5
Benzo (ghi) perylene	<5		